[*Frontispiece, Vol. xxxii.*]

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TRANSACTIONS

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TURNER, CHARLES EDWARD, Mina Campanario, Valverde del Camuio, Provincia de Huelva, Spain. N. E.

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WOOD, HON. EDWARD, Garrowby, Bishop Wilton, York. M. I.
WRIGHTSON, WILFRID INGRAM, Neasham Hall, Darlington. N. E.

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Associates.

Assoc. Inst. M.E.

Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines or metallurgical works, or employed in analogous positions in other branches of engineering.

* Deceased.

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ALLAN, HERBERT DURHAM, Rewah State Collieries, Umaria, Central India, Bengal Nagpur Railway. N. E.
ALLCOCK, JAMES, Hornscroft, Bolsover, Chesterfield. M. C.
ALLPORT, EDWARD ASTON, Lound House, Haxey, Doncaster. N. E.
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ARMOUR, WILLIAM, Deanfield, Irvine. S. I.
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MARSHALL, JOHN JOSEPH. N. E.
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Stud. Inst. M.E.

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TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
TO RECEIVE THE MEMBERS OF
THE AMERICAN INSTITUTE OF MINING ENGINEERS,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 1ST, 1906.

The LORD MAYOR (Sir Joseph Baxter Ellis) extended to the members of the American Institute of Mining Engineers a most hearty and kindly welcome, not only to England but to the Metropolis of the North. He need not say how highly they appreciated the visit of so important an institute to the heart of the iron-and-steel industry of England. It was interesting to know that when visiting Middlesbrough they had seen the great works and the immense progress that had been made; but that great and wonderful industry of Tees-side owed much of its prosperity to Newcastle-upon-Tyne and to the men who had gone there from Newcastle, many years ago, in the persons of the late Sir Lowthian Bell, Sir Hugh Bell, Mr. H. W. F. Bolckow and Mr. J. Vaughan. These men laid down what had proved to be a great industry on the banks of the Tees. He hoped that the visitors would see many things of interest, while they were in the district.

The PRESIDENT (Mr. T. W. Benson), on behalf of The North of England Institute of Mining and Mechanical Engineers, welcomed the visitors to the ancient city of Newcastle, and to the oldest coal-field in Great Britain. Early in the fourteenth

century coal was worked at Elswick by the prior and brethren of Tynemouth, and the burgesses of Newcastle worked coal near the place where they were then assembled. The appliances were primitive, and horses were used for haulage, until George Stephenson and William Hedley invented their locomotive engines. The safety-lamp was invented by Dr. William Reid Clanny and by George Stephenson, so that the district was the birthplace of many inventors who had improved the methods of mining.

CAPTAIN ROBERT W. HUNT (Chicago), President of the American Institute of Mining Engineers, said that the Lord Mayor was quite right when he spoke of the influence of Newcastle, and they knew it, even in America, and one of his best friends in Chicago was a Newcastle man. He did not wonder that Englishmen loved England, and the moment that one put one's foot on the shores the beauties of the land captured one. He returned thanks for the welcome that had been given them and for the hospitality which they knew they were going to receive.

The following notes record some of the features of interest seen by the visitors to the collieries, which were, by kind permission of the owners, thrown open for inspection during the course of the meeting on August 1st and 2nd, 1906:—

pumps. It was then decided to freeze the shafts, so as to sink through the remaining thickness of Magnesian Limestone, and 92½ feet of Yellow Sands, in a frozen state, rather than erect additional pumping plant.

In April, 1903, preparatory to freezing, 28 bore-holes were sunk around each shaft, to a depth of 484 feet and 21 feet into the Coal-measures. The bore-holes were completed in April, 1904; and freezing was then commenced, and continued until February 16th, 1906. During this period both shafts were sunk through the frozen limestone and sand into the Coal-measures, and the whole of the water-bearing strata was lined with cast-iron tubbing.

The shafts are, at present, being sunk through Coal-measures. The Castlereagh shaft, at a depth of 810 feet, is passing through the "filtering post," containing a feeder of water amounting to about 100 gallons a minute, and this water is being drawn by the winding-engine. The Theresa shaft is sunk to a depth of 780 feet, into the filtering post, where a feeder of water amounting to 100 gallons a minute has been encountered; and this water is being drawn with the sinking engine, until arrangements are made to deal with it.

The total length of cast-iron tubbing in the Castlereagh shaft is 456 feet, and below this there is 108 feet of brickwork. The total length of tubbing in the Theresa shaft is 438 feet, and below this is 204 feet of brickwork.

There are two sinking-engines, each with cylinders 24 inches in diameter, and 4 feet stroke; and drums 8 feet in diameter and 6 feet wide. The locked-coil ropes are 3¾ inches in circumference.

Steam is supplied from eight Galloway boilers, 30 feet long and 8 feet in diameter, working at a pressure of 100 pounds per square inch. There are four sets of Green fuel-economizers, each fitted with 120 tubes.

There are two Archbutt-Deeley water-softeners capable of treating 60,000 gallons of water per day. The water is reduced from 16 degrees to 4 or 5 degrees of hardness by the treatment: 40 pounds of lime and 7 pounds of alkali being used for each tank of water treated, at a cost of ½d. per 1,000 gallons.

The horizontal winding-engine at the Castlereagh shaft, with two cylinders, 40 inches in diameter and 6 feet stroke, fitted with

Corliss valves, has a parallel drum, 20 feet in diameter and 10 feet wide. It is drawing water from a tank in the Castlereagh shaft. A sister-engine is being erected at the Theresa shaft.

The walls for the heapstead and screening plant are in course of erection.

HORDEN COLLIERY.

The total area of the royalties leased and owned by The Horden Collieries, Limited, is about 19,000 acres. The Shotton and Horden collieries have been opened out and developed during the past six years to work a portion of this property, and it is intended at a later period to open out and develop two more collieries at Hesleden and Castle Eden respectively. At the present time, the production averages 2,500 tons of coal per day.

The three shafts at Horden were sunk through the Magnesian Limestone, before entering the Coal-measures at a depth of about 1,050 feet. The north and south downcast shafts are 20 feet, and the east upcast shaft is 17 feet, in finished diameter.

The north shaft is sunk to the Hutton seam at a depth of 1,200 feet, the total depth of the shaft being 1,260 feet. Sinking was commenced on November 6th, 1900, and completed on July 22nd, 1904. In this shaft, water was met with at a depth of 198 feet, and from this point downwards to a depth of 522 feet, the shaft is secured with cast-iron tubbing. Above and

[redacted]

men and materials underground, and for lifting coal from the level of the Harvey seam. The north shaft will be used for working the Hutton and Low Main seams; and the south shaft for working the Five-Quarter and Main coal-seams.

During the sinking of these shafts, continuous pumping over a period of three years was necessary, in handling from 3,000 to nearly 10,000 gallons of water per minute in passing through the Magnesian Limestone and Yellow Sands before the Coal-measures were reached.

The tandem-compound winding-engine has four cylinders, 21 inches and 36 inches in diameter by 5 feet stroke taking steam at a pressure of 160 pounds per square inch, fitted with Frew balanced slide-valves and automatic expansion-gear. The two drums on each crank-shaft are 16 feet in diameter and 5 feet wide. The locked-coil winding ropes are 1¾ inches in diameter, and the unbalanced load consists of 4 tons 4 cwts. of coal. The double-decked cages contain 4 tubs on each deck; and the tubs on the top decks are discharged by hydraulic rams simultaneously with those on the bottom deck.

The first portion of the screening plant, consisting of three main picking-belts and cross-belts for small and nut coal, is driven electrically.

The sirocco fan, driven electrically, will produce 350,000 cubic feet of air per minute, at a water-gauge of 4 inches. It has just been completed and set to work.

Visits were also made to the Hylton* and Wearmouth† collieries of the Wearmouth Coal Company, Limited; the Dunston coal-shipping staithes of the North-eastern Railway Company;‡ the north pier of the Tyne Harbour;§ the Wallsend and Walker works of Messrs. Swan, Hunter and Wigham Richardson, Limited;|| the Elswick works of Sir W. G. Armstrong, Whitworth & Company, Limited;¶ Alnwick and Bamburgh castles; and the Roman camps, etc., at the Chesters and Housesteads.

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 149.
† *Ibid.*, page 152. ‡ *Ibid.*, page 172. § *Ibid.*, page 158.
|| *Ibid.*, page 187. ¶ *Ibid.*, page 177.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 4TH, 1906.

MR. T. W. BENSON, RETIRING-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the Proceedings of the Council at their meetings on July 21st and that day, and of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1906-1907.

The CHAIRMAN (Mr. T. W. Benson) appointed Messrs. Norman B. Ridley, Arthur Mundle, Mark Ford and W. B. Wilson, junr., as scrutineers of the balloting-papers for the election of officers for the year 1906-1907.

The SCRUTINEERS afterwards reported the result of the ballot, as follows:—

[redacted]

Mr. J. G. WEEKS seconded the resolution, which was cordially adopted.

Mr. J. H. MERIVALE thanked the members for the honour that they had conferred upon him. He moved a vote of thanks to the Retiring-President, Vice-Presidents, Councillors and Officers for their services during the past year.

Mr. HENRY LAWRENCE seconded the motion, which was heartily adopted.

Mr. R. S. ANDERSON moved a vote of thanks to the representatives of this Institute on the Council of The Institution of Mining Engineers for their services during the past year.

Mr. A. MUNDLE seconded the proposal, which was cordially adopted.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1905-1906.

The Council regret to have to refer to the great loss that the Institute has sustained through the death of Mr. William Logan, a vice-president of the Institute, 1902-1905, and a member since 1867.

The sad and appalling explosion which took place at the Courrières colliery, the number of lives lost exceeding that of any previous colliery disaster, is greatly to be regretted, and appreciation can only be expressed of the arduous and valuable services that were rendered by the exploring and rescue-parties.

The following table shows the progress of the membership during recent years:—

Year ending August 1st.	1900.	1903.	1906.
Honorary Members	30	26	25
Members	883	921	931
Associate Members	132	112	114
Associates	108	161	190
Students	59	69	56
Subscribers	23	23	33
Totals	1.235	1.312	1,349

Although 99 members of all classes have been added to the register during the past year, there has been a decrease of 3 members, owing to exceptional losses by death, resignations, etc.

The Library has been maintained in an efficient condition during the year; the additions, by donation, exchange and purchase, include 390 bound volumes and 47 pamphlets, reports, etc.; and the Library now contains about 10,900 volumes and 337 unbound pamphlets. A card-catalogue of the books, etc., contained in the Library renders them readily available for reference.

Members would render useful service to the profession, by presentations of books, reports, plans, etc., to the Institute, to be preserved in the Library and thereby become available for reference.

Mr. Frederick Charles Keighley of Uniontown, Fayette County, Pennsylvania, U.S.A., represented the Institute at the celebration of the two-hundredth anniversary of the birth of Benjamin Franklin, the founder of the American Philosophical Society.

G. C. Greenwell gold, silver and bronze medals may be awarded anually for approved papers "recording the results of experience of interest in mining, and especially where deductions and practical suggestions are made by the writer for the avoidance of accidents in mines."

G. C. Greenwell bronze medals have been awarded to [redacted]

"Note on the Composition of Coal from the Faröe Islands." By Mr. Roger Dodds.
"Notes on Safety-lamp Oils." By Dr. George Percy Lishman, Assoc. M.I.M.E.
"The Miners' Worm-disease, as seen in Westphalian and Hungarian Collieries." By Dr. Thomas Oliver.
"The Action, Influence and Control of the Roof in Longwall Working." By Mr. Edward Heton Roberton.
"The Development of Explosives for Coal-mines." By Mr. Donald M. D. Stuart, M.I.M.E.
"Note on the Calorific Effect of Coal from the Faröe Islands." By Mr. R. R. Thompson.
"Note on the Composition of Dover Coal." By Mr. R. R. Thompson.

During the past year, the concluding part of the *Report of the Committee upon Mechanical Coal-cutting* was issued to the members, who are greatly indebted to the members of the Committee for this exceedingly valuable report. Mr. H. F. Bulman has received an honorarium in recognition of his services as engineer to the Committee.

A Committee has been appointed to enquire into the treatment of coal-dust in collieries, and the results of their investigations will be communicated to the members in due course.

At the instance of the Council, Prof. Henry Stroud, instructed Mr. G. C. Wood, a research-student at the Armstrong College, to make measurements of the specific electrical resistances of the different substances found in mines, and the results of these investigations, communicated by Mr. G. C. Wood, have been printed in the *Transactions.*

The papers printed in the *Transactions* during the year are as follows: —

"The Lander Anemometer."
"A Conveyor for Filling Coal at the Face." By Mr. Léon André.
"Improved Dampers for Coke-oven Flues." By Mr. William Archer, M.I.M.E.
"The Application of Direct Cementation in Shaft-sinking." By Mr. C. Dinoire.
"A Mechanical Coal-cutter in Queensland." By Mr. William Fryar.
"The Great Planes of Strain in the Absolute Roof of Mines." By Mr. Henry Wallace Gregory Halbaum, M.I.M.E.
"Corundum in Ontario, Canada: Its Occurrence, Working, Milling, Concentration and Preparation for the Market as an Abrasive." By Mr. David Gillespie Kerr, M.I.M.E.
"The Alumino-thermic Welding Process, and its Application to General Engineering." By Mr. J. Stewart MacGregor.
"The Unwatering of the Achddu Colliery, with a Description of the Riedler Express Pump." By Mr. John Morris, M.I.M.E.

"Undersea Extensions at the Whitehaven Collieries, and the Driving of the Ladysmith Drift." By Mr. John Shanks, M.I.M.E.

"The Barton and Forcett Limestone-quarries." By Mr. Thomas Teasdale, M.I.M.E.

"Determination of the Specific Electrical Resistance of Coal, Ores, etc." By Mr. G. C. Wood.

Excursions were made to Dawdon colliery in September, 1905, and to the Elswick works of Sir W. G. Armstrong, Whitworth & Company, Limited, in June, 1906.

The Institution of Mining Engineers has now completed its seventeenth year, and the members are to be congratulated upon its continued success. Meetings have been held during the past year in Manchester in September, 1905, and in London in June, 1906.

The CHAIRMAN (Mr. T. W. Benson) moved the adoption of the Annual Report of the Council.

Mr. J. H. MERIVALE seconded the motion, which was adopted.

The Report of the Finance Committee was read as follows:—

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1906, duly audited.

[redacted]

has been paid for work done in connection with the supplementary volume to *An Account of the Strata in Northumberland and Durham, as proved by Borings and Sinkings*, and £60 8s. 7d. for the fitting of panels in the Lecture Theatre.

The figures given above show that the total income exceeded the expenditure by £343 10s. 5d., and adding to this the balance of £553 9s. 1d. in hand at the beginning of the year, there is a sum of £896 19s. 6d. to carry forward.

The names of 47 persons have been struck off the membership-list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £203 18s., of which £115 16s. was for sums due for the year 1905-1906, and £88 2s. for arrears. It is probable that a considerable proportion of these amounts will be recovered by the solicitors, and will be credited in future years. Of the amounts previously written off, £94 8s. was recovered during the past year.

JOHN B. SIMPSON.

August 4th, 1906.

Mr. J. H. MERIVALE moved the adoption of the Annual Report of the Finance Committee.

Mr. THOMAS DOUGLAS seconded the resolution, which was adopted.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1906-1907.

The CHAIRMAN (Mr. T. W. Benson) moved, and Mr. George May seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1906-1907:—

Mr. R. DONALD BAIN.	Mr. G. C. GREENWELL.	Mr. W. C. MOUNTAIN.
Mr. BENNETT H. BROUGH.	Mr. REGINALD GUTHRIE.	Mr. HENRY PALMER.
Mr. C. S. CARNES.	Mr. T. E. JOBLING.	Mr. M. W. PARRINGTON.
Mr. W. COCHRAN CARR.	Mr. AUSTIN KIRKUP.	Mr. F. R. SIMPSON.
Mr. FRANK COULSON.	Mr. PHILIP KIRKUP.	Mr. JOHN SIMPSON.
Mr. THOMAS DOUGLAS.	Mr. C. C. LEACH.	Mr. J. B. SIMPSON.
Mr. T. E. FORSTER.	Prof. HENRY LOUIS.	Mr. J. G. WEEKS.
Mr. J. W. FRYAR.	Mr. J. H. MERIVALE.	Mr. W. O. WOOD.
	Mr. JOHN MORISON.	

The resolution was agreed to.

Dr. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND
FOR THE YEAR ENDING

		£ s. d.	£ s. d.
June 30th, 1905.			
To Balance of Account at Bankers		500 17 11	
„ „ in Treasurer's hands		47 12 8	
„ Outstanding Accounts due from Authors for Excerpts		4 18 6	
			553 9 1
June 30th, 1906.			
To Dividend of 7½ per cent. on 179 Shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the Year ending June 30th, 1906 ...		268 10 0	
„ Interest on Mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited		49 0 0	
			317 10 0
To Sales of *Transactions*			44 4 3
To SUBSCRIPTIONS FOR YEAR 1905-1906 AS FOLLOWS:—			
752 Members	@ £2 2s.	1,579 4 0	
86 Associate Members	@ £2 2s.	180 12 0	
139 Associates	@ £1 5s.	173 15 0	
44 Students	@ £1 5s.	55 0 0	
45 New Members	@ £2 2s.	94 10 0	
12 New Associate Members	@ £2 2s.	25 4 0	
16 New Associates	@ £1 5s.	20 0 0	
16 New Students	@ £1 5s.	20 0 0	
		2,148 5 0	

[redacted]

INSTITUTE OF MINING AND MECHANICAL ENGINEERS — CR.
JUNE 30TH, 1906.

June 30th, 1906.		£ s. d.	£ s. d.
By *An Account of the Strata of Northumberland and Durham, as proved by Borings and Sinkings* ...		52 10 0	
„ *Annual Report*		35 17 9	
„ Banker's Charges		21 5 7	
„ Circulars and Advance Copies of Papers		49 19 2	
„ Cleaning Wood Memorial Hall, Offices, etc.		46 18 10	
„ Electric Light		25 19 5	
„ Expenses of Meetings		3 3 1	
„ Fire Insurance		13 5 9	
„ Fuel		18 2 7	
„ Furniture and Repairs		22 15 0	
„ Illustrations		2 10 0	
„ Incidental Expenses		5 9 8	
„ Lecture Theatre		60 8 7	
„ Library—Binding	£64 16 0		
„ „ Books	23 11 11		
		88 7 11	
„ Petty Cash		4 4 3	
„ Postages—Circulars	£31 15 6		
„ „ Correspondence	15 13 10		
„ „ Publications	29 11 3		
		77 0 7	
„ Prizes for Papers		15 15 0	
„ Rates and Taxes		6 3 6	
„ Rent of Offices		24 14 0	
„ *Report of the Committee upon Mechanical Coal-cutting*		114 13 5	
„ Reporting of General Meetings		12 12 0	
„ Salaries, Wages, Auditing, etc.		472 3 2	
„ Stationery, etc.		26 19 11	
„ *Subject-matter Index of Mining, Mechanical and Metallurgical Literature*		7 10 0	
„ Telephone Rent		3 3 6	
„ Translations of Papers		4 5 0	
„ Water Rate		3 7 8	
			1,219 5 4
By The Institution of Mining Engineers		1,327 16 6	
Less—Amounts paid by Authors for Excerpts ...		2 11 0	
			1,325 5 6
			2,544 10 10
By Balance of Account at Bankers		840 11 3	
„ „ in Treasurer's hands		53 9 9	
„ Outstanding Accounts due from Authors for Excerpts		2 18 6	
			896 19 6
			£3,441 10 4

Dr. The Treasurer of The North of England Institute of Mining

		£	s.	d.	£	s.	d.	£	s.	d.
To 953 Members,										
52 of whom have paid Life-compositions.										
901										
6 not included in printed list.										
907	@ £2 2s.	...	...	...	1,904	14	0			
To 113 Associate Members,										
8 of whom have paid Life-compositions.										
105	@ £2 2s.	...	...		220	10	0			
To 178 Associates,										
1 of whom has paid a Life-composition.										
177	@ £1 5s.	...	...		221	5	0			
To 56 Students,										
56	@ £1 5s.	...	...		70	0	0			
To 28 Subscribing Firms										
28		...	...		107	2	0	2,523	11	0
To 44 New Members	@ £2 2s.	92	8	0						
1 New Member, not yet elected	@ £2 2s.	2	2	0						
45					94	10	0			
To 12 New Associate Members	@ £2 2s.				25	4	0			
To 16 New Associates	@ £1 5s.	...	...		20	0	0			
To 16 New Students	@ £1 5s.	...	...		20	0	0			

[redacted]

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1905–1906. CR.

		PAID. £	s.	d.	UNPAID. £	s.	d.	STRUCK OFF LIST. £	s.	d.
By 752 Members, paid	@ £2 2s.	1,579	4	0	......			......		
By 110 ,, unpaid ...	@ £2 2s.	......			231	0	0	...		
By 3 ,, excused payment	@ £2 2s.	......			......			6	6	0
By 6 ,, dead	@ £2 2s.	......			......			12	12	0
By 36 ,, struck off list	@ £2 2s.	......			......			75	12	0
907										
By 86 Associate Members, paid	@ £2 2s.	180	12	0	......			......		
By 16 ,, ,, unpaid	@ £2 2s.	......			33	12	0	......		
By 1 ,, ,, excused	@ £2 2s.	......			......			2	2	0
By 1 ,, ,, dead	@ £2 2s.	......			......			2	2	0
By 1 ,, ,, struck off list		... ..			......			2	2	0
105										
By 139 Associates, paid	@ £1 5s.	173	15	0	......			......		
By 28 ,, unpaid ...	@ £1 5s.	......			35	0	0	......		
By 2 ,, excused ...	@ £1 5s.	......			......			2	10	0
By 8 ,, struck off list	@ £1 5s.	......			......			10	0	0
177										
By 44 Students, paid	@ £1 5s.	55	0	0	......			......		
By 10 ,, unpaid ...	@ £1 5s.	......			12	10	0	......		
By 2 ,, struck off list...	@ £1 5s.	......			......			2	10	0
56										
By 25 Subscribing Firms, paid		90	6	0	......			......		
By 3 ,, ,, unpaid		......			16	16	0	......		
28										
By 45 New Members, paid ...	@ £2 2s.	94	10	0	......			......		
By 12 New Associate Members, paid	@ £2 2s.	25	4	0	......			......		
By 16 New Associates, paid ...	@ £1 5s.	20	0	0	......			......		
By 16 New Students, paid ...	@ £1 5s.	20	0	0	......			......		
By 5 New Subscribing Firms, paid	@ £2 2s.	10	10	0	......			......		
		2,249	1	0	328	18	0	115	16	0
By Arrears		287	16	0	90	17	0	88	2	0
		2,536	17	0						
By Subscriptions paid in advance		49	19	0	......			......		
		2,586	16	0	419	15	0	203	18	0
								419	15	0
								2,586	16	0
								£3,210	9	0

MINING AND MECHANICAL ENGINEERS: GENERAL STATEMENT, JUNE 30TH, 1906.

	s.	d.	£	s.	d.
...			49	19	0
...			2	19	6
	0	0			
	8	4			
			32	11	8
...			12,219	7	6

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			£12,304	17	8

ASSETS.

	£	s.	d.	£	s.	d.
Balance of Account at Bankers	840	11	3			
,, in Treasurer's hands	53	9	9			
Outstanding Accounts due from Authors for Excerpts	2	18	6			
				896	19	6
Arrears of Subscriptions				419	15	0
179 Shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100	0	0			
Investment with the Institute and Coal-trade Chambers Company, Limited (mortgage) ...	1,400	0	0			
				5,500	0	0
(Of the above amount, £1,586 is due to Life-subscriptions Account.)						
Value of *Transactions* and other Publications, as per Stock Account	338	3	2			
Books, Pictures, Maps, Furniture and Fittings	5,150	0	0			
				5,488	3	2
				£12,304	17	8

G. C. GREENWELL MEDALS.

The CHAIRMAN (Mr. T. W. Benson) said that the medals were founded by their late friend Mr. G. C. Greenwell, who, as the older generation of the members knew, was an original member of the Institute, one of the early members of the Council, and a past-president. He had pleasure in presenting G. C. Greenwell medals to Messrs. W. C. Blackett and R. G. Ware for their most useful and practical paper on "The Conveyor-system for Filling at the Coal-face, as practised in Great Britain and America."* It was deeply to be regretted that one of the recipients—Mr. R. G. Ware—had died since the paper was written; and he was sure that it was the desire of the members that the Secretary, in forwarding the medal to the mother of the deceased gentleman, should convey their regrets and deepest sympathy.

Mr. W. C. BLACKETT said that he was very grateful to the Council for the honour done to him, although his pleasure in receiving the Greenwell medal was sadly marred by the fact that Mr. Ware, who had been awarded a companion medal, had passed away. He was glad that the relatives that he had left would receive some little comfort from the fact that this distinction was paid to him after his death.

The CHAIRMAN (Mr. T. W. Benson) handed to Mr. M. Walton Brown the G. C. Greenwell medal awarded to Mr. D. M. D. Stuart for his paper on "The Development of Explosives for Coal-mines."†

Mr. M. WALTON BROWN, in acknowledging the receipt of the medal, said that Mr. Stuart was very gratified to receive the Greenwell medal awarded to him for his paper upon "The Development of Explosives for Coal-mines." He assured the Council that he very deeply appreciated the honour that they had conferred upon him, and he would treasure that high distinctive recognition of his endeavour to contribute, in however small a way, to the great work of the Institute in promoting the safety of mining.

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* *Trans. Inst. M. E.*, 1905, vol. xxix., page 449.

† *Ibid.*, page 299.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr Edward William Andrews, Electrical Engineer, 4, Ashwood Terrace, Sunderland.

Mr. Owain Tudor Edwards, Mining Engineer, care of The G. I. P. Railway Company, Mopani Collieries, Central Provinces, India.

Mr. Ernest Long, Electrical Engineer, care of Messrs. W. T. Glover and Company, Limited, Trafford Park, Manchester.

Mr. Augustin Joseph McInerny, Mining Engineer, 16, Rue d'Autriche, Tunis.

Mr. William Roberts, Mining Engineer, Bella Vista, Perranporth, S.O., Cornwall.

ASSOCIATE MEMBER—

Mr. Andrew Selby Wood, Caledonian Buildings, Pilgrim Street, Newcastle-upon-Tyne.

STUDENT—

Mr. John Anthony Sydney Ritson, Mining Student, Burnhope Colliery, Lanchester, Durham.

[redacted]

AN APPLIANCE FOR AUTOMATICALLY STOPPING AND RESTARTING MINE-WAGONS.*

BY PROF. W. GALLOWAY.

The points at which this appliance can be most usefully employed are at the weighing-machine between the top of the shaft and the screens, and in front of the cage at the top and bottom of the shaft. Its functions are to arrest the motion of a full or empty wagon without shock, to hold it stationary as long as may be necessary, and then to push it forward, with any desired velocity, in the direction in which it was originally moving. These operations are accomplished without the intervention of an attendant, except that, at the instant of restarting, a lever is moved either by hand or foot which requires only the smallest imaginable exertion of force on the part of the weigher, banksman, or hitcher, as the case may be. By this appliance, all the weighing on the surface and the loading and unloading of the cages at the top and bottom of the shaft have been effected automatically, and without a hitch, for upwards of a year, at Garth colliery, near Maesteg, South Wales, belonging to Messrs. Elder's Navigation Collieries, Limited.

Figs. 1, 2 and 3 (Plate I.) represent a sectional elevation, a plan and an end elevation respectively, of its application to a weighing-machine. A rectangular sheet-iron frame, *A*, sliding on eight supports, *b*, two on each side of the cylinder, *C*, and two fixed to each end of the frame which surrounds the weighing-platform, carries a set of Fisher catches, *c* and *c'*, which always occupy the positions shown in Fig. 1, when left to themselves. The frame, *A*, is attached to a piston-rod, *B*, which passes through a stuffing-box (in which metallic packing is used by preference), and is fixed to a piston, *d*, in the interior of the cylinder, *C*. A pipe, *e*, with a valve, *o*, which is always open unless some unexpected emergency arises, connects the inside of the cylinder

* British patent, 1904, No. 25,344.

on the left-hand side of the piston with the air-compressing engine, which is common to all the other compressed-air machines used at the colliery. Another pipe, *g*, with a valve, *p*, which is regulated to suit requirements, connects the ends of the cylinder with each other. A third pipe, *f*, with a valve, *q*, which is opened when the foot-plate, *m*, is pressed down, and is closed automatically by the weight, *t*, passes from the right-hand end of the cylinder under the floor of the weighing-machine house to a point where the foot-plate is convenient to the weigher, and thence out again from under the floor at the other side of the house. The compressed air has thus a free passage into the cylinder on both sides of the piston, and thence into the pipe, *f*, as far as the valve, *q*.

When the valve, *q*, is shut, the air within the cylinder is at the same pressure on both sides of the piston; but the area of the left-hand side of the piston being less than that of its right-hand side by the amount of the area of the piston-rod, the piston, the piston-rod, the frame attached to it, and any wagon that happens for the moment to be held between the catches, are drawn towards the left-hand side as far as the piston can move. The force with which a movement towards either the left- or right-hand side is effected depends on the relative areas of the piston and piston-rod on the one hand and the pressure of the air on the other, all of which must be taken into account when the required forces are calculated. In approaching the left-hand end of the cylinder, the piston covers the open-

[redacted]

to a foot, according to the greater or less velocity at which the wagon has been moving. But the pressure of the air within the cylinder, now acting like a spring, arrests the forward motion of the wagon and then draws it back until it stands directly over the centre of the weighing-platform. The operation of weighing having been completed, the weigher places his foot on the foot-plate and thereby opens the valve, *q*. The air-pressure, being thus withdrawn from the right-hand side of the piston, the latter, together with the frame, is pushed towards the right-hand side and the catches, *c*, pressing against the hinder axle of any wagon that happens to be in front of them, drive it forward at a greater or less velocity, according to the greater or less diameter of the cylinder and the higher or lower pressure of the air acting on the piston. When the frame has nearly reached the end of its intended stroke, a knob, *n*, on the end of a rod, *h*, attached to a crank, *l*, on the shaft, d'', to which the catches, c', are keyed, comes into contact with a spring, *s*, in front of a standard, *k* (fixed to the weighing-platform), through a hole in which the rod, *h*, can pass freely. The spring arrests the forward movement of the rod: the catches, c', are thereby depressed; and the wagon, continuing to run forward after the frame has come to a standstill, passes over them, and proceeds towards its destination. As soon as the hinder axle of the wagon is clear of the catches, c', the weigher removes his foot from the foot-plate, the valve, *q*, closes automatically, the pressure of the air on the right-hand side of the piston is restored through the pipe, *g*, and the valve, *p*, and the frame, *A*, is drawn back to its original position, ready to receive another wagon. The rapidity with which the frame is drawn back depends on the area of the opening of the valve, *p*. The frame, *A*, is covered with a sheet of iron to prevent coal or rubbish from falling into its interior, and the only openings in it are those through which the catches, *c* and c', project.

The valve, *p*, can be closed and opened by the same lever as that which opens and closes the valve, *q*; in fact this is applied in the apparatus employed at the weighing-machine at Garth colliery. In the same apparatus, a chain with a spring is used, instead of the rod, *h* (Figs. 1 and 2, Plate I.). A slide-valve can be used, in place of the valves, *p* and *q*; vertical catches held up by springs or counter-weights acting on levers

can be used, instead of the Fisher catches; steam or water, under pressure, can be used, instead of compressed air; and the details can thus be varied in many ways.

The points to be specially noted are: that the moving wagons are arrested gently, held in the desired position, and again discharged with the required velocity without muscular effort on the part of an attendant, and that, thereby, a substantial saving in both time and labour, is effected.

The average rate at which tubs, each carrying 1 ton, can be stopped, steadied, weighed and disposed of by this apparatus in the manner described, as applied at Garth colliery, is six per minute, or, more accurately, one tub per 9·58 seconds. The time occupied in pushing a full or empty tub of the same capacity into the cage and thereby discharging the empty or full tub, in front of it, is about 3 seconds.

Mr. J. G. Weeks said that the apparatus described by Mr. Galloway probably removed the difficulty arising from men pressing on the tubs while they were on the weighing-machine. Contrivances were in use in this district, which carried out the same object, without using compressed air, electricity or steam, as they were simply actuated by the weight of the tub being pushed against the apparatus. It was a great advantage in [redacted]

Mr. J. H. MERIVALE, in seconding the vote of thanks, said that, if the apparatus was combined with some arrangement for running the tubs out of the cage, it would be exceedingly useful. Still, except for the purpose suggested by Mr. Weeks, he did not see how they would derive much advantage from automatic weighing, as they must always have a banksman in attendance.

Mr. W. C. BLACKETT pointed out that, in the case described in the paper, the loading and unloading of the cages at the top and bottom of the shaft was done automatically, so that a banksman would not necessarily be in attendance.

Mr. C. B. PALMER said that, at Felling colliery, the tub was never touched by a workman after leaving the cage until it came to the tippler. It was crept automatically over the weighing-machine, it was weighed while moving, upon a long weigh-bridge, and it was therefore unnecessary for anyone to touch the tub while on the weighing-machine.

Mr. W. GALLOWAY stated that the apparatus could be made to deal with any weight of tub, large or small, and that it was in constant use for running tubs into and out of the cages, both at the top and bottom of the Garth colliery, near Maesteg. The latter point appeared to have escaped the notice of Mr. Merivale.

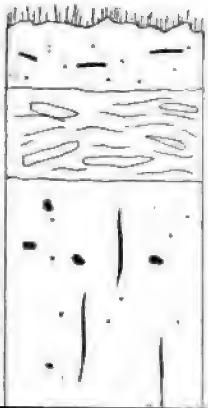
The vote of thanks was cordially adopted.

Dr. J. A. SMYTHE's paper on "Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham" was read as follows:—

DEPOSITS IN A PIT-FALL AT TANFIELD LEA, TANTOBIE, COUNTY DURHAM.

By J. A. SMYTHE, M.Sc., Ph.D.

Introduction.—This pit-fall, as seen on May 15th, 1905, was a round hole about 24 feet across and 12 to 15 feet deep. The section on the west side showed an old peat-bed, underlain by sandy clay; the peat thinned out quickly to the east, and the



Description of Strata.	Thickness of Strata. Feet.	Depth from Surface. Feet.
Soil, containing a few slabs of flaggy sandstone, made ground (?)	1	1
Peat, with stumps, roots and branches ...	2	3
Sandy clay, with "black stuff" in pockets and rifts	6	9

from its occurrence only beneath it (and from chemical evidence to be given shortly), there can hardly be any doubt that it was derived from it. Some of the larger pockets, about 1 foot below the peat-bed, yielded 2 or 3 cubic inches of the deposit.

Analyses.—The deposit was seen to have a conchoidal fracture and a concentric arrangement of layers, and it could be peeled somewhat like a boiled onion; on drying in air it lost 76 per cent. of water and formed a hard black substance with conchoidal fracture, grinding to a dark brown powder. The peat and the partly decomposed wood embedded in it, formed brown powders on drying and grinding. These three bodies will be referred to hereafter as black stuff, peat and wood.

Under the microscope, the black stuff appears as a greenish-yellow transparent body, stratified, but quite devoid of any plant structure. The air-dried samples gave on analysis:—

	Moisture.	Ash.	Volatile Matter.	Fixed Carbon.
Black stuff	16·43	7·23	55·55	20·79
Peat	16·05	9·75	49·44	24·76
Wood	14·12	4·12	56·00	25·76

All three yield friable cokes or cokey powders, and the ash is white in the case of the peat, buff in that of the other two. For better comparison these results are here recalculated on the basis of dry ash-free material:—

	Volatile Matter.	Fixed Carbon.
Black stuff	72·80	27·20
Peat	66·66	33·34
Wood	68·48	31·52

These figures bring out clearly the similarity of the peat and wood. The somewhat higher percentage of volatile matter in the black stuff is what might be expected, on the assumption that it is derived from the peat by some process of solution and deposition. The ultimate analysis of the dry materials gave:—

	Carbon	Hydrogen.	Nitrogen.	Sulphur.	Ash.	Oxygen (by difference).
Black stuff ...	49·22 49·36	5·14 5·16	2·33 2·49	1·41	11·23	30·51
Peat	—	—	1·55	—	—	—
Wood	—	—	0·92	—	—	—

The low percentage of total carbon and the high percentage of volatile matter suggest that the black stuff is similar rather

to the carbohydrates than to coal. This is brought out clearly in the following table, in which the black stuff is compared with three of the typical carbohydrates, namely, cellulose, starch, and cane-sugar.

	Total Carbon	Total Hydrogen.	Volatile Matter.	Fixed Carbon.
Cellulose	44·44	6·17	87·60	12·40
Starch	44·44	6·17	83·52	16·48
Cane-sugar	42·11	6·44	79·85	20·15
Black stuff (ash-free) ...	55·54	5·80	72·80	27·20

Reference may perhaps be made here to the rise in the percentage of nitrogen which accompanies the metamorphosis of the vegetable matter. According to Prof. A. Delesse,* the woody parts of plants contain less nitrogen than the leaves, and mosses are fairly rich in that element. It is thus not unnatural that the peat, which is only partly made up from wood, should contain more nitrogen than the wood embedded in it, and that the black stuff, which has lost all woody structure, should contain most nitrogen of all.

Extraction with Solvents.—Dry chloroform dissolves about 1 per cent. by weight of the black stuff, peat and wood after 3 hours' extraction. The yellow solution leaves a waxy solid on evaporation of the chloroform, and this solid, on purification by dissolving in benzene and precipitating with petroleum-ether, is obtained in the form of a greenish powder, melting about 90° Cent. and burning with a long, smoky flame when heated on [redacted]

of the constituents richer in hydrogen, and, furthermore, that the presence of these constituents influences in a remarkable way the coking power of the coal. Thus a coal with moderate coking properties is rendered non-coking by treatment with pyridine, but the pyridine extract has greatly enhanced coking properties compared with the original coal.

Exactly similar phenomena are met with in studying the solvent action of pyridine upon the black stuff from Tantobie. Not only do the pyridine solutions resemble those from coal, but the extracts are richer in volatile matter (and presumably in hydrogen also), and they coke much more readily than the original stuff itself, and still more so than the extracted residue. Thus, proximate analysis of the residue and extract from the pyridine treatment of the black stuff gave the following results:—

	Volatile Matter.	Fixed Carbon.	Ash.
Extract ...	79·24	20·29	0·47
Residue ...	48·04	37·41	14·55

The original and the residue both gave a cokey powder; the extract yielded a compact glistening coke. Comparing these results with the original black stuff, and recalculating all on ash-free material, the results are as follow:—

	Volatile Matter.	Fixed Carbon.
Black stuff	72·80	27·20
Extract	79·64	20·36
Residue	56·30	43·70

Mr. Baker's results* from the pyridine extraction of coal from the Hutton seam may be compared with the foregoing. Mr. Baker's figures are here recalculated on the dry ash-free material:—

	Volatile Matter.	Fixed Carbon.
Coal	30·96	69·04
Extract	54·45	45·55
Residue	32·84	67·16

It will be noticed that, both in the case of the coal and of the Tantobie black stuff, the volatile matter is greater in the pyridine extract, and smaller in the insoluble residue, than in the original materials; and corresponding to this, the extracts yield better cokes than the original bodies or the insoluble residues.

* *Trans. Inst. M. E.*, 1900, vol. xx., page 160.

It is thus evident that, in respect to the action of pyridine, and to the coking properties of the original material and the products of extraction, the black stuff bears the closest analogy to bituminous coal. That it should also resemble, in some ways, the carbohydrates, as pointed out above, is perhaps not unnatural when the connection between cellulose and coal is considered.

Some recent deposits having, apparently, some of the characters of the Tantobie black stuff have been described by Prof. H. Potonié.* They are formed on the Ahlbecker See from muddy matters containing animal and vegetable remains, and are fermented in the absence of oxygen. The consistency of these muds is that of a jelly; they show a delicate stratification and a conchoidal fracture very like the bituminous shales with *Cypridina* of the Coal-measures. They are so rich in nitrogen as to be worked for the extraction of ammonia.

The author wishes, in conclusion, to express his best thanks to Messrs. W. A. Swallow and T. Adamson, of Tanfield Lea colliery, for having brought this matter to his notice and for having given him every facility to examine the pit-fall; to Mr. E. Jeffrey, B.Sc., of the Armstrong College, for carrying out the four nitrogen determinations embodied in the text; and to Prof. G. A. Lebour for the references to the foreign literature quoted in the paper.

[redacted]

ELECTRO-BAROGRAPH FOR MINES.*

The Thwaite electro-barograph has been invented to secure the automatic and audible signalling of a sudden and dangerous drop of mine-pressure.† It consists of an aneroid barometer, A, fitted with three dry cells, B, and a signal-bell, C (Fig. 1). The contact-maker, *a*, may be adjusted at the beginning of each shift, or any other appointed time, so that the pointer, *b*, is placed at the

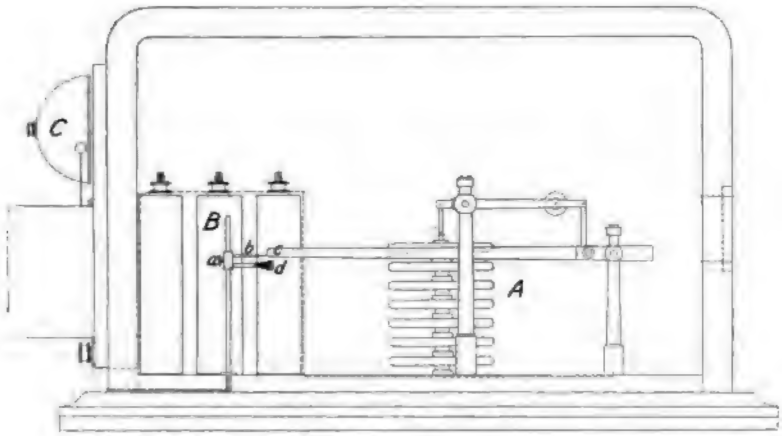


FIG. 1.—ELEVATION OF THWAITE ELECTRO-BAROGRAPH.

level of the underside of the bar, *c*. The distance between the pointer, *b*, and the brush or contact-maker, *d*, is adjusted to the requirements of each mine. As soon as the bar, *c*, of the barometer falls a certain distance, measured by the interval between the pointer, *b*, and the brush, *d*, electric contact takes place between the bar, *c*, and the brush, *d*, and the bell rings, wherever the instrument is placed in the mine.

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* British patent, October 7th, 1905, No. 20,291.

† "Can Explosions in Coal-mines, with their associated Toxic Fatalities, be prevented," by Mr. B. H. Thwaite, *Trans. Inst. M. E.*, 1905, vol. xxx., page 389.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
JULY 9TH, 1906.

MR. J. C. CADMAN IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—

Mr. HARRY G. PIGGFORD, Bengal Coal Company, Limited, Sanctoria Collieries, Barakar, East India Railway, India.

Mr. JOSEPH RAMSDEN, Madeley Coal, Coke and Brick Company, Limited, Newcastle, Staffordshire.

Mr. HUGH L. WILKINSON, Bengal Coal Company, Limited, Laikdie Collieries, Chirkunda, *via* Barakar, East India Railway, India.

ASSOCIATE—

[redacted]

NOTES ON THE FEED-WATER OF COLLIERY-BOILERS.

BY A. E. COOKE.

At the present time coal is being won from great depths, and as these depths are likely to be exceeded in the future, an increased consumption of steam will be rendered necessary. Further, as the question of steam-raising is of importance at collieries, if it is to be increased by future developments, it will deserve more attention than it has had in the past.

It is not proposed to go into the whole question of steam-raising, but rather to demonstrate the utility of some apparatus for dealing with the hard waters which often have to be used in colliery-boilers. It is only of comparatively late years that this subject has been taken up by the mining engineers of this country; but it is now generally recognized to be an important factor in the life of the boiler, and as such it requires, from an economic point of view, careful attention and the soundest knowledge that can be brought to bear upon it, this knowledge being best obtained by observations of detail and the application of scientific principles. To these points the writer has endeavoured to pay attention, to the former in practice, and to the latter by experiments made in the laboratory. It often happens that the boiler feed-water is supplied from underground and is of excessive hardness; and, where there is a great deal of water, a heavy pumping cost is incurred. When the feed-water has to be bought from neighbouring authorities this will necessitate its being used economically, which means the erection of surface-condensers, so that the exhaust-steam may be utilized as much as possible.

In such a case as this, an efficient appliance for softening the underground water and making it fit for use as feed-water would be welcomed as a boon.

The advantages claimed for softening water by the most

approved method are as follows:—(1) Increased calorific power; (2) lessened deposit of scale; (3) boilers easier to clean; (4) diminution of pitting, corrosion and grooving; (5) reduced danger from overheated plates; (6) increased life of the boilers; (7) feed-water pipes kept clear; and (8) prevention of priming.

The chief causes of the hardness of water are due to the presence of dissolved carbonates and sulphates, which have accumulated as the water has percolated downwards.

There is some diversity of opinion as to how and when the water should be treated, whether before or after entering the boiler. The latter method is often recommended for small collieries, though why, it is difficult to say: decidedly not on economic grounds, unless the water is but slightly hard, in which case only would it be advisable. In this latter instance, the remedy used is called a "boiler-doctor," and there are numerous varieties of it in the market. The amount used depends on the nature of the water, and may vary from ½ pint to 1 pint per boiler per day, the action being to prevent the formation of the deposit altogether, or to render its removal easier. In this method, however, there seems to be insufficient provision made against priming, due to the rapid evolutions of gas or alkaline water.

A case occurred not long ago, which came under the writer's observation, where, after the adoption of a "boiler-doctor," corrosive action was noticed on the piston-rod, and on further

[redacted]

cleaning (a very common occurrence), then the addition of the "boiler-doctor," say of the ammonium-chloride type, has this effect:—$CaCO_3 + 2NH_4Cl = CaCl_2 + (NH_4)_2CO_3$. The ammonium carbonate passes away readily with the steam, often causing priming; and the calcium chloride, however, being very soluble in water, is held in solution. Further proof of this action may be seen in the result of two simple experiments, showing really what does take place inside the boiler; although the tests are not quantitative and have been made with the ammonium-chloride type of "boiler-doctor." (1) Experiment to prove that priming may occur: add ammonium chloride to water containing calcium carbonate in solution and heat it over a Bunsen flame. Ammonium carbonate gas is given off, priming is evident and calcium chloride is left in solution. (2) Experiment to show the solubility of calcium chloride in water: take lime-water and add carbon dioxide by exhalation until the lime-water becomes turbid, then add a solution of ammonium chloride, and continue as in the former experiment; it will be noticed that the turbidity quickly disappears and no deposit is visible.

In other cases, which have come under the writer's personal observation, the only noticeable result, after the adoption of a "boiler-doctor," has been to soften the deposit, that is to say, not to get rid of it, but to make the cleaning of the boiler much easier, and upon investigation, this "doctor" was found to be of sodium-carbonate type. Other "boiler-doctors" have been analysed and found to contain compounds, which are simply added for the sake of appearance: no other construction can be placed upon their presence, as they have no effect whatever on the water, other than colour or smell.

It is not contended that the method already described and the method to be described subsequently, are the only ones in vogue for the treatment of boiler-waters, because it often occurs that there are local remedies, or rather, they would perhaps be better named if called partial remedies. But these are adopted on economic grounds, and undoubtedly have a beneficial effect, tending to minimize the evil resulting from the use of a bad feed-water and may be quite as efficacious as a "boiler-doctor"; still, as they depend upon local conditions, they are not capable of general application, for which reason they are not included in this paper.

The hardness of water is generally due to the presence of certain metallic salts in solution, usually the carbonates and sulphates of calcium and magnesium, and sometimes, in addition, the chlorides of magnesium and calcium: the former salts, on being heated with water, form the deposits of scale in the boiler. If the water is treated before it enters the boiler, the procedure is totally different.

It is possible to soften hard water by boiling, provided that the hardness be due to the presence of carbonates only: the carbonates being deposited by boiling, thus $CaH_2(CO_3)_2 = H_2O + CO_2 + CaCO_3$. The soluble acid lime carbonate is decomposed into water, carbon dioxide which escapes as a gas, and the insoluble normal carbonate is precipitated.

This method is rarely adopted on a large scale, but slaked lime is used, its action being to precipitate the carbonates, either of calcium or magnesium, thus $CaH_2(CO_3)_2 + CaO = H_2O + 2CaCO_3$. The soluble lime salt is thus converted into the insoluble normal carbonate.

To remove sulphates, another common remedy may be used, ordinary soda (sodium carbonate). The reaction is as follows: $CaSo_4 + Na_2CO_3 = Na_2SO_4 + CaCO_3$. The soluble calcium sulphate is then converted into insoluble calcium carbonate, which is precipitated.

Sodium sulphate and chloride are very soluble and pass into the boiler, but they are not deposited on the boiler-plates; neither is there danger to be feared from priming, because the carbonate [redacted]

hardness to the presence of sulphates and chlorides. Both kinds of hardness are spoken of in degrees or grains of calcium carbonate per gallon, the sum of both being called the total hardness of the water. It is unnecessary to state here details as to how the degrees and grains per gallon are arrived at, except that the degree of hardness is obtained from a test made with a standard soap-solution. From past experience, it has been found that water of 5 or 6 degrees of total hardness does not require softening; but if, by application of the above test, the water is found to be excessively hard, then it requires treatment.

Respecting the amount of lime or soda required, this depends on the hardness of the water, whether temporary or permanent, and the degrees of hardness of each, and from these available data the amount required can be accurately calculated.

The necessary plant for treating water on this principle is usually designed to deal with large quantities, and is therefore out of the question for small collieries, because of the prohibitive initial cost, the system of treating being all that could be desired for simplicity and efficiency. The difficulty of initial cost could, however, be overcome to a large extent by the adoption of old boiler-shells as treating tanks: this would allow of a proper method of treating being proceeded with.

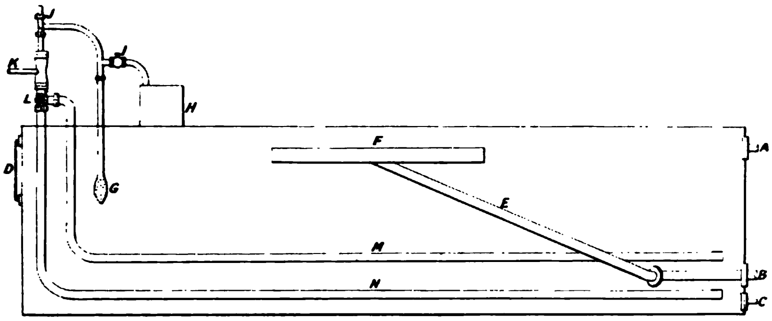


FIG. 1.—TANK FOR TREATING HARD WATER. SCALE, 8 FEET TO 1 INCH.

The arrangement (Fig. 1) is quite adaptable and practicable. The water is admitted through the supply-pipe, *A*, into the tank; when nearly full, as indicated by a water-gauge, *D*, the supply is cut off and the treatment may be proceeded with. Steam is admitted through a blower, *K*, and passes into the tank by way of the pipe, *M*. This causes a current of water to circulate upwards through the perforated nozzle, *G*, through a three-way tap, *L*.

down the vertical pipe to the horizontal pipe, *M*, and so back into the tank. This horizontal pipe, *M*, has perforations on its upper side. The tap, *I*, is then opened, and the prepared chemical solution from the mixing tank, *H*, is drawn slowly into the circulating current, and by this means is evenly diffused throughout the contents of the tank. The air-tap, *J*, is next opened and the tap, *L*, reversed, so causing the air to be forced into the pipes, *N*, near the bottom of the tank, passing into the tank by means of perforations on the lower side of this pipe. The object of the lower pipe is to assist precipitation: the air travels upwards from the perforations, in streams of bubbles, stirring up some of the precipitate left from previous operations, lying on the tank-bottom, and thoroughly mixing it with the new mixture that has just been added. If the old sediment had not been disturbed, the process of precipitation would be very slow, because the new precipitate is so finely divided; but, on mixing with the coarser particles of the old sediment, the fine particles become attached to them and are more readily precipitated.

The length of time of this agitation varies with the hardness of the water, but 10 to 15 minutes is usually occupied, during which the water becomes thoroughly treated; after which the blower, *K*, is shut off and the precipitate allowed to settle. The settling will probably last an hour, after which the water may be drawn off through the discharge-pipe, *E*. It will be noticed that the top water is being drawn off all the time, by means of a pipe suspended by a float, *F*, which keeps the mouth of the

[redacted]

The disadvantages of either method of treatment may be briefly stated to be as follows:—A. "Boiler-doctors," (1) costly method of treatment; (2) liability to cause priming; (3) liability of feed-water pipes becoming choked (owing to bad state of water); and (4) liability to affect metals in contact with them: internal corrosion, pitting and grooving, having been known to occur. In addition to the actual cost of the compound, there is the additional cleaning required, and particularly is this the case where the feed-water passes through economizers before treatment, as these tubes are very difficult to clean and often have to be bored out to remove the deposit B. Tank-treatment, the initial cost high, but maintenance is slight.

As the advantages have been already stated, it is unnecessary to repeat them, except to add, that they are all claimed for this last-named method of treatment in particular.

In an instance of this method of treatment, the tanks used were square, having a capacity of 12,000 gallons each; the total hardness of the water was 70 degrees, that is to say, 70 grains per gallon and it was required to reduce this to 4 degrees of total hardness; to do this, 8 pounds of quicklime and 22 pounds of soda were required; and the total cost of softening was less than 1d. per 1,000 gallons.

The necessity for the adoption of either method of treatment should be determined upon economic grounds, due consideration being given to the excessive wear-and-tear and cleaning of boilers, feed-water or economizer pipes, the risks of priming, possibility of corrosion, and the comparatively high cost of "boiler-doctors" on the one hand; and on the other, the necessary accommodation and the rather heavy initial outlay involved, which, however, is counterbalanced by the slight cost of maintenance afterwards.

It is estimated that, to supply a range of ten boilers, with a capacity for evaporating 14,400 gallons of water each in 24 hours (total 144,000 gallons), four tanks would be required, each tank consisting of an old boiler-shell, 30 feet long and 8 feet in diameter, and each tank being subjected to four operations daily; this would mean 144,000 gallons receiving treatment, and as 1½ hours is sufficient for each operation, the total time occupied in treating is 6 hours per tank, so that if more water is required. it can easily be dealt with at the tanks.

The CHAIRMAN (Mr. J. C. Cadman) considered that there was no district in England where the feed-water for boilers required treating, in a manner similar to the one pointed out by Mr. Cooke, more than in North Staffordshire. He remembered a colliery, at Chesterton, where they had about the worst water in England to put into the boilers. They considered that they were fortunate when, without artificial means, an improvement was effected by their being enabled to obtain the effluent-water from a sewage-farm, and it answered the purpose remarkably well.

Mr. E. B. WAIN said that, with regard to the purification of feed-water for boilers, there was no more difficult district perhaps than North Staffordshire. It was not an infrequent thing to find that water for boiler purposes contained 90 to 120 grains of mineral solids per gallon; and that meant that for every month's work there would be 1½ to 2 tons of solids left in an ordinary Lancashire colliery-boiler. The methods of treatment Mr. Cooke had referred to, were those which were generally adopted. The "boiler-doctors" spoken of were generally what might be termed quack doctors, if they might judge by the large number of circulars one received almost every day from some firm of manufacturers, who had got the only thing that could soften boiler-scales. They were all based upon some form of carbonate of soda or caustic soda, with the addition of colouring or other foreign matter. Mr. Cooke had, however, brought out the point more particularly that the best place for treating the water was

[redacted]

in a simple manner (without any chemical re-agents) with the impurities in the boiler-water. He had found that that method was the cheapest and most efficient way of dealing with hard water that contained 80 to 100 grains of mineral solids to the gallon.

Mr. B. Woodworth presumed that the cost named was for materials simply, and did not include the cost of the plant or attendance. He asked whether the air was supplied under pressure.

A vote of thanks was accorded to Mr. Cooke for his paper.

MANCHESTER GEOLOGICAL AND MINING SOCIETY AND NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT HULTON, BOLTON, JULY 30TH, 1906.

HULTON COLLIERY COMPANY, LIMITED.

ATHERTON, NOS. 3 AND 4 PITS.

Winding-engines.—The No. 3 pit winding-engine, with two cylinders, each 32 inches in diameter, and a cylindrical drum 15 feet in diameter, is winding from the depth of 900 feet. The No. 4 pit winding-engine, with two cylinders 36 inches in diameter and a cylindrical drum 18 feet in diameter, is winding from two different mines at depths of 450 feet and 1,320 feet respectively. Both engines are controlled by foot- and steam-brakes, and the ropes are fitted with Ormerod safety detaching-hooks.

Boilers.—There are eight boilers, four working at a pressure of 100 pounds per square inch, and four at 150 pounds per [redacted]

capable of standing 25 per cent. of overload for 2 hours, and run at 3,000 revolutions per minute. The circulating water for the condensers, of the ejector-type, is supplied by two motor-driven centrifugal pumps.

These generators supply power for the whole of the work at the Nos. 3 and 4 pits, with the exception of winding, and for a considerable portion of the work at the Chequerbent and Atherton No. 1 pits. The power is conveyed to the latter by means of an overhead transmission-line, about 1¼ miles long, the pressure being raised at the power-house to 3,300 volts. At Chequerbent pits, the current is applied, without stepping down, to a ventilating fan, driven by a motor of 150 horsepower and to two motors of 125 horsepower, driving direct-current generators.

The large switchboard in the power-house controls the supply of power to the Nos. 3 and 4 pits, and the small one, the high-voltage transmission-line.

Three transformers, situated on the lower floor, are each of 120 kilowatts capacity.

Electric driving is applied to ventilating, screening, pumping, hauling, coal-cutting, boiler-feeding, forced draught, sawing, air-compressing, briquette-making, and other purposes. There is also an extensive lighting installation.

Banking and Screening.—The cages are of the two-decked type, holding three tubs on each deck. The tubs on leaving the cage gravitate to a creeper-chain, which conveys them to the weighing-machine at a higher level.

The tipplers are mechanically driven, and the screening is done by means of shakers. The empty tubs from the tipplers gravitate round a curve to a creeper-chain, which raises them to a higher level, whence they gravitate to the back of the pit. The picking-belts are made of wire-webbing, and the coal is lowered into the wagons by means of mechanically-controlled lowering arms. The small sizes of coal are stored in bunkers, from which the coal is run into wagons by means of trap-doors, as required.

Railway-sidings.—The railway-sidings lead under the screens, and thence to the wagon weighing-machine, and a diversion from the main-line leads to the briquette-siding and briquette-house.

The sidings are so laid that the railway-wagons gravitate gently to the various points of call, and pass away again when liberated. The services of the locomotive are not required from the beginning of this operation until the wagons have been filled, weighed, and placed in the sidings.

Shafts.—There are two shafts, and coal is at present being wound from three mouthings:—The Trencherbone mine, at a depth of 450 feet; the Yard mine, at a depth of 900 feet; and the Arley mine, at a depth of 1,320 feet.

All the underground roadways have been laid out with a view to facilitate the quick handling of coal.

The Trencherbone mine is equipped with an electrical hauling-engine of the endless-rope type. The mine is ventilated by an underground Sirocco fan, 30 inches in diameter, rope-driven by an electric motor of 30 horsepower, producing about 20,000 cubic feet of air per minute at 1 inch of water-gauge.* There are two large three-throw pumps driven by an electric motor: one, near the pit, pumping about 10,000 gallons of water per hour. A Hurd coal-cutter is working in this mine.

The Yard mine is equipped with an electric hauling-engine of the endless-rope type. It is ventilated by an underground Sirocco fan, 45 inches in diameter, rope-driven by an electric motor of 45 horsepower, and producing about 50,000 cubic feet of air per minute at $1\frac{1}{4}$ inches of water-gauge.

[redacted]

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD AT LOW MOOR, JULY 19TH, 1906.

MR. T. W. H. MITCHELL, RETIRING-PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

Messrs. H. Baddeley and James Gregory were appointed scrutineers of the balloting-lists for the election of Officers and Council, and also for representatives of the Institute on the Council of The Institution of Mining Engineers for 1906-1907.

The following gentlemen and colliery firms, having been duly nominated, were elected:—

MEMBERS—

Mr. DIETRICH BENTHAUS, Mechanical and Consulting Engineer, Telephone Buildings, Commercial Street, Sheffield.

Mr. ROBERT CLIVE, Colliery Manager, Bentley Colliery, Doncaster.

Mr. THOMAS HANSON COCKIN, Mining Engineer, 120, Harcourt Road, Sheffield.

Mr. JOSHUA LISTER INGHAM, Director of Ingham Thornhill Collieries, Blake Hall, Mirfield, S.O., Yorkshire.

Mr. JAMES THOMAS WATSON, Inspector of Collieries, Wollongong, New South Wales.

Mr. WILLIE WOODHEAD, Colliery Manager, Beeston Colliery, Leeds.

ASSOCIATE MEMBER—

Mr. WILLIAM PETRIE, Mechanical Engineer, Hickleton Main Colliery, Thurnscoe, near Rotherham.

SUBSCRIBERS—

The CARLTON MAIN COLLIERY COMPANY, Limited, Colliery Proprietors, Barnsley.

The MITCHELL MAIN COLLIERY COMPANY, Limited, Colliery Proprietors, Barnsley.

Messrs. POPE & PEARSON, Limited, Colliery Proprietors, Altofts, Normanton.

The Annual Report of the Council and the Accounts were read and adopted, as follows:—

ANNUAL REPORT OF THE COUNCIL, 1905-1906.

The Council has pleasure in presenting its Annual Report for the past year to the members of the Institute.

The number of members who have paid their subscriptions for the year is 308. A comparison with the numbers for the year 1904-1905 is shewn in the following table:—

	1904-1905.	1905-1906.
Life Member	1	1
Members (Class *a*)	264	272
Associate Members (Class *b*)	10	11
Associates (Class *d*)	11	7
Students (Class *e*)	16	17
Totals	302	308

At the date of closing the accounts, subscriptions were due from 13 members.

26 members were elected during the year, namely: 15 members, 2 associate members and 9 students. 18 members have resigned since July 1st, 1905.

The Council regret to have to record the death of four members during the year, namely: Mr. E. Brown, Mr. E. F. D. Mosby, Mr. G. Spooner, and Mr. Hargreaves Walters.

Thirteen subscriptions in arrear for the year 1904-1905 have

[redacted]

The Council has had the question of increased membership under its consideration. It strongly feels that the usefulness of the Institute might be extended if the number of its members were larger, and urges members to use their influence to secure new members. Steps have also been taken to secure the support of colliery companies, and the Council have pleasure in announcing that five companies have signified their intention of subscribing to the funds of the Institute.

The balance at the bank on July 1st, 1905, was £243 1s. 11½d., of which £160 has been invested in Great Northern Railway 4 per cent. guaranteed stock at a cost of £196 2s. 10d. The balance at the bank for the year just passed is £46 7s. 5d. and the cash in the Treasurer's hands, £2 12s. 9d.

The Annual Dinner was held at Barnsley on November 8th, 1905, at which 110 members and guests were present. After dinner, the members were entertained at an "At Home" at the invitation of the President (Mr. T. W. H. Mitchell).

Four meetings were held during the year, including a joint meeting with the Midland Counties Institution of Mining Engineers. At these meetings the following papers have been read:—

"The Reavel Air-compressor at Work." By Mr. W. Price Abell.

"Supplementary Remarks on Systematic Timbering at Emley Moor Collieries." By Mr. H. Baddeley.

"Practical Notes on Ropes and Capels." By Mr. E. Barraclough.

"'Black Ends,' their Cause, Cost and Cure." By Mr. T. Beach.

"The Stanley Double Heading Machine." By Mr. Arthur Hall.

"An Account of Sinking and Tubbing at the Methley Junction Colliery, with a description of a Cast-iron Dam to resist Outbursts of Water." By Mr. I. Hodges.

"Further Notes on Capels for Winding-ropes." By Mr. T. W. H. Mitchell.

The papers read were of a thoroughly practical character, and dealt with subjects of great importance and interest. The number of papers is smaller than last year, when ten papers were read. This is partly due to the fact that one meeting was given over to the discussion of papers only, at which, in accordance with the resolution of the Council of May 23rd, 1905, Mr. W. E. Garforth introduced a discussion on systematic timbering and methods of controlling the roof in longwall working. The joint meeting was largely attended, and papers of considerable interest were read and discussed.

[redacted]

…A) IN ACCOUNT WITH THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS, 1905–1906. CR.

	£	s.	d.
…. d.			
2 11			
9 0½			
	243	1	11½
0 0			
0 0			
0 0			
0 0	486	10	0
0 0			
3 2	31	13	2
2 0			
3 9			
	11	15	9
…	3	0	0
…eers'			
…	0	19	3
…	0	12	9
…	10	10	0
…d on			
…x …	3	0	10
…	5	14	10
…ors.			
	£796	18	6½

	£	s.	d.	£	s.	d.
June 30th, 1906.						
By The Institution of Mining Engineers:—						
„ Call of 19s. on 314 Members for 1905-1906	298	6	0			
„ „ „ 28 „ 1904-1905	26	12	0			
„ „ 20s. 1 „ „	1	0	0			
„ Excerpt *Transactions*, etc. … …	4	17	8			
„ Exchanges … … … …	7	10	2			
	338	5	10			
„ *Less* £1 4s. 3d. overpaid. 1904-1905 …	1	4	3			
				337	1	7
„ Messrs. A. Reid & Co. Ld., advance copies	2	17	6			
„ *Sheffield Independent Press* … …	1	5	0			
				4	2	6
„ Printing and stationery … … … …				34	16	9
„ Rent and cleaning of rooms … … … …				25	9	6
„ Rent of telephone … … … … …				7	5	0
„ Insurance … … … … … …				0	3	0
„ Hire of rooms for meetings at Barnsley and Leeds				3	1	0
„ Secretary's salary and expenses … … …				54	19	10
„ Stamps and carriage … … … … …				13	17	10½
„ Annual dinner … … … … …				34	3	3
„ North of England Institute, Report on Mechanical Coal-cutting, 100 copies at 3s. … … …				15	0	0
„ Expenses of joint meeting … … … …				1	18	6
„ Cataloguing library … … … … …				12	0	1
„ Subscription to Congrès International Economique				0	16	8
„ Reporter… … … … … …				7	0	0
„ £160 G.N.R. 4% Guaranteed Pref. Stock … …				196	2	10
„ Cash in Treasurer's hands … …	2	12	9			
„ Balance at bank … … …	46	7	5			
				49	0	2
				£796	18	6½

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS: GENERAL STATEMENT, 1905-1906.

LIABILITIES.

	£ s. d.	£ s. d.	£ s. d.
June 30th, 1906.			
To Creditors:—			
„ Prize Essay Fund			10 10 0
„ Life Member's Subscription			27 0 0
„ Subscriptions paid in advance			8 0 0
„ Institution of Mining Engineers—Calls on two members			1 18 0
„ *Capital* as at June 30th, 1905 ...		634 10 10½	
„ *Less* Subscription paid in advance, 1904-1905, and not taken as a liability		1 10 0	
		633 0 10½	
„ *Add* Outstanding Subscriptions at that date ...	34 10 0		
„ *Less* treated as bad ...	15 0 0		
		19 10 0	
„ *Add* Increase in value of assets, viz., 128 copies of *Transactions*	6 8 0		
„ 1 Narrative of Gas Outbursts	0 1 0		
„ 28 copies of North of England Institute Report on Mechanical Coal-cutting	4 4 0		
		10 13 0	
		663 3 10½	
„ *Less* Life Members' Subscriptions at that date		28 10 0	
		634 13 10½	
„ *Less* Transferred from Income account		1 2 10½	
			633 11 0
			£680 19 0

ASSETS.

	£ s. d.	£ s. d.
June 30th, 1906.		
By Cash at bank	46 7 5	
„ „ in Treasurer's hands	2 12 9	
		49 0 2
„ Great Northern Railway Company, £160 4% Guaranteed Stock cost		196 2 10
„ Book-case as at June 30th, 1905 ...	34 0 0	
„ *Less* depreciation written off ...	3 8 0	
		30 12 0
„ Value of 7,341 parts of *Transactions* at 1s. ...		367 1 0
„ Value of 116 copies of Narrative of Outbursts of Gas, at 1s.		5 16 0
„ Value of 116 copies of Committee's Report on Safety-lamps, at 1s.		5 16 0
„ Value of 16 copies of Report of French Commission on Use of Explosives, at 3s.		2 8 0
„ Value of 9 copies of Report of the Prussian Commission on Falls of Stone, at 1s.		0 9 0
„ Value of 28 copies of North of England Institute Report on Mechanical Coal-cutting, at 3s. ...		4 4 0
„ Outstanding Subscriptions (1904-1905) received since June 30th, 1905		19 10 0
		£680 19 0

Examined and found correct,

M. H. HABERSHON,
THOMAS GILL,
AUDITORS.

The question of the delay that exists in the publication of the reports of Institute meetings has engaged the attention of the Council during the past year. To avoid postponing the discussion of papers until they have appeared in the *Transactions*, advance-copies of the papers to be read at the meetings have been sent to every member whenever possible. This has entailed considerable expense in postage and extra printing; the expense in postage would be avoided, if members contributing papers would send the manuscript to the Secretary at least one month before the meeting. With the object of preventing the delay in the future the Council has given its hearty support to the Council of the Midland Counties Institution of Mining Engineers in its action in bringing this matter before the Council of The Institution of Mining Engineers.

The Report of the Committee of the North of England Institute of Mining and Mechanical Engineers on Mechanical Coal-cutting was published during the year. As 67 applications for copies were made by members, the Council purchased 100 copies and distributed the 67 copies at cost price.

The Sections Committee is proceeding with the work of editing the sections supplied by the members, and the Council is pleased to report that the Director of the Geological Survey and Museum has consented to publish the sections of the Nottinghamshire and Derbyshire coal-fields in the same volume with the Yorkshire sections. As mentioned in last year's report, the Council of the Midland Counties Institution of Mining Engineers [redacted]

Chambers and J. R. R. Wilson were appointed assessors to make the awards. They reported that two of the essays contributed by students were worthy of prizes, and recommended that the associate's prize for which there was no candidate should be awarded to the student candidate whose essay was placed second in order of merit. The following prizes were awarded:—First prize for essay by "Vernier," Mr. Norman W. Routledge; and second prize for essay by "Scotsman," Mr. Augustus John Kennedy. The Council, in thanking the donor for his generous offer, begs to assure him that by his action he has rendered a valuable service to the Institute, in encouraging study and research among its members.

A vote of thanks was passed to the examining committee, consisting of Mr. W. E. Garforth, Mr. J. R. R. Wilson, and Mr. W. H. Chambers.

ELECTION OF OFFICERS AND COUNCIL, 1906-1907.

The Scrutineers reported the result of the ballot, as follows:—

President:
Mr. J. R. Robinson Wilson.

Vice-Presidents:

Mr. I. Hodges.	Mr. J. L. Marshall.	Mr. W. Walker.

Councillors:

Mr. J. E. Chambers.	Mr. M. H. Habershon.	Mr. E. W. Thirkell.
Mr. H. St. J. Durnford.	Mr. Walter Hargreaves.	Mr. G. R. Thompson.
Mr. J. J. Eley.	Mr. R. Rowand.	Mr. W. Washington.
Mr. Thomas Gill.	Mr. T. Stubbs.	Mr. A. Woodhead.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1906-1907.

Mr. W. H. Chambers.	Mr. T. W. H. Mitchell.	Mr. G. B. Walker.
Mr. W. E. Garforth.	Mr. H. B. Nash.	Mr. J. R. R. Wilson.
Mr. I. Hodges.	Mr. J. Nevin.	

Mr. J. R. Robinson Wilson, in returning thanks for his election, said that he took it as the greatest honour that the members could confer upon him. He could also accept it as an indication

that one of H.M. inspector of mines, in spite of the trammels of his office, had the same interests as themselves; the chief of them being the progress of scientific mining. He ventured to hope, and thought it was a laudable ambition, that his term of office might be a record one; and he would like to feel at its close that some progress had been made, that the membership had increased, and that they had done good work. There was no question that in that district they had some of the finest types of collieries, and he need hardly say before that meeting, that they had also some of the most skilled engineers. If they, as individuals, would take upon themselves the responsibility of looking after the welfare of the Institute, they were bound to succeed and become second to none.

The PRESIDENT (Mr. J. R. Robinson Wilson) moved a vote of thanks to Mr. T. W. H. Mitchell for his services as president during the past two years. The name of Mitchell had been honourably associated with the Institute for a great number of years. Father and son had always had its interests at heart, and the very least they could do on that occasion was to place on record their feeling of hearty thanks.

Mr. W. E. GARFORTH seconded the resolution, which was carried.

Mr. T. W. H. MITCHELL said that whatever he had done in connexion with the Institute had been a labour of pleasure. He [redacted]

THE PNEUMATOGEN: THE SELF-GENERATING RESCUE-APPARATUS, COMPARED WITH OTHER TYPES.

By R. CREMER.

The principle on which modern rescue-apparatus are constructed, consists in purifying the exhaled air of the user by means of suitable chemicals for absorbing the carbonic acid and moisture, and by restoring the consumed oxygen from receptacles containing the gas in a compressed state.

For storing the gas, more or less heavy and cumbersome steel cylinders are required, and in order to obtain satisfactory results it has been found necessary to add numerous mechanical appliances, which not only considerably increase the weight, but also add more or less to the complication of the apparatus, as is seen in the better known types, such as the Shamrock, Giersberg and Draeger apparatus.

Ever since the invention of forms of apparatus in which compressed oxygen is used and especially since they took their present form, efforts have been made to find a substitute for compressed oxygen, by using chemical compounds which would absorb the carbonic acid of the breath and simultaneously generate oxygen.

As described in the early literature on the subject, and as also mentioned by Mr. G. A. Meyer in his paper on "Rescue-apparatus"* read before The Institution of Mining Engineers last month, Prof. Théodore Schwann, of Liége, many years ago endeavoured to construct an apparatus in which hydrated barium peroxide acted as the oxygen-generator and air-filtering material; but he failed to obtain any satisfactory results by this method, and had to adopt the use of compressed oxygen, according to the principle introduced by Messrs. V. Regnault and J. Reiset.† This apparatus was the forerunner of the various forms of breath-

* "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party," by Mr. G. A. Meyer, 1906, *Trans. Inst. M. E.*, vol. xxxi., page 575.

† "Recherches chimiques sur la Respiration des Animaux des diverses Classes," by Messrs. Victor Regnault and Jules Reiset, *Annales de Chimie et de Physique*, third series, 1849, vol. xxvi., page 401; and *Annalen der Chemie und Pharmacie*, 1850, vol. lxxiii., page 264.

ing apparatus of the present day, in which compressed oxygen is used, and it led later to the construction of the Fleuss apparatus. After the explosion at the Karwin collieries ten years ago, the question of life-saving apparatus was revived by Mr. Walcher von Uysdal and from that time rescue-apparatus had become more or less an indispensable part of the equipment of collieries and other mines. By the exertions of Mr. Uysdal, together with those of Prof. G. Gärtner, of Vienna, and Mr. H. Rössner, the manager of the Karwin collieries, the pneumatophore* was presented to the mining world, and in a short time was adopted by many collieries: subsequently, by an order of the Austrian Mining Department, all collieries in the Ostrau-Karwin coal-district were compelled to provide the apparatus. Soon endeavours were made to improve the original form of the pneumatophore, and by the energetic action of Mr. J. Mayer and Mr. F. Wanz in Austria, Mr. G. A. Meyer, of Berlin, Mr. B. Draeger, of Lubeck, and others, various types of apparatus were devised.

The unavoidable disadvantages arising from the use of compressed oxygen, however, revived the idea of supplying this gas by generating it by chemical means brought about by the respiration of the wearer.

In the apparatus of Messrs. A. Desgrez and V. Balthazard,† alkaline peroxides were periodically projected into water by means of clock-work or an electric accumulator, the solution produced serving to absorb the carbonic acid. This apparatus [redacted]

following extract is given from their paper on "Apparatus for Self-rescue from Irrespirable Gases"*:—"The first considerations that we had in mind were the following: lightness, compactness, simplicity in handling, absolute guarantee of security in use, durability, and low cost. To avoid the disadvantages of compressed oxygen we endeavoured to produce the oxygen in such quantities as are required for breathing by chemical means; and at the same time avoid the use of heavy and complicated valves and pressure-regulators." Like Messrs. Balthazard and Desgrez, these inventors first used sodium peroxide in the form of sticks or balls, which were thrown, by mechanical appliances, into water at certain intervals. The exhaled air was made to pass over the sodium peroxide, which absorbed the carbonic acid, by means of mica-valves in a manner similar to that adopted in the pneumatophore.

One great disadvantage of this method of generating the oxygen was the high temperature produced by the chemical reaction, in consequence of which the air was returned to the user at rather a high temperature. Whilst Messrs. Desgrez and Balthazard met this drawback by using low boiling methyl chloride to cool the air, the inventors of the pneumatogen considered this method unsuitable to the conditions laid down by them. Another disadvantage was that, at the commencement of breathing, the absorption of the carbonic acid was far from satisfactory, because the caustic-soda solution was dilute and less active.

In order to absorb the large amount of moisture and the last traces of carbonic acid in the regenerated air, the inventors adopted, instead of the solution, solid sodium peroxide as the absorbing material and the oxygen-generator simultaneously. Thus great simplicity was attained, but the result was hardly practical: because, in the first instance, it was not easy to obtain the chemicals in a proper size and porous state, and, in the second, it was necessary to divide the apparatus into two parts, namely, the absorption and air-regenerating chamber, and the oxygen-generating chamber.

Later the inventors found that the production of oxygen was considerably greater, and the construction of the appar-

* "Athmungsapparat zur Selbstrettung aus dem Bereiche irrespirabler Gase," by Professor Max Bamberger and Dr. Friedrich Böck, *Zeitschrift für angewandte Chemie*, 1904, vol. xvii., page 38.

atus much simplified if the sodium peroxide were replaced by higher peroxides having a similar action with regard to carbonic acid and moisture. Of such higher peroxides, potassium-sodium peroxide ($KNaO_3$), free from dust, in coarse pieces and in a porous state, was found most suitable. This compound yields twice as much oxygen as sodium peroxide. A smaller quantity of this, therefore, will suffice to change the exhaled products into breathable air within a certain time.

The reactions which take place may be expressed as follows:—

$$\text{I.}\quad KNaO_3 + H_2O = KHO + NaHO + O_2.$$

$$\text{II.}\quad CO_2 + KHO + NaHO = KNaCO_3 + H_2O.$$

$$\text{III.}\quad CO_2 + KNaO_3 = KNaCO_3 + O_2.$$

From which it is seen that the oxygen set free is not only equal to the carbonic acid absorbed, but a further quantity is liberated by the absorption of the water, and the exhaled air becomes richer in oxygen, a result which, with reference to small leakages or diffusion-processes, is well worthy of consideration.

A vertical section of the generator of the rescue-apparatus constructed after this principle is shown in Fig. 1 (Plate II.), whilst in Figs. 13 to 15, the pneumatogen I. type, and in Figs. 16 to 19, the pneumatogen II. type are reproduced.

The essential part of the apparatus, the generating cartridge, shown in Fig. 1 (Plate II.), is constructed as follows:—The potassium-sodium peroxide is placed in a cylindrical metal box, [redacted]

By breaking the lead seals, and at the same time making a tight connection with the respiratory organs of the user on the one hand, and the breathing-bag on the other, communication is established with the contents of the cartridge and thus the apparatus is ready for use.

In the first type of the pneumatogen, intended and constructed for self-rescue, as shown in Figs. 13 to 15, the cartridge (as described) is held by a frame consisting of two movable parts: each of these parts carries perforating crowns, which are so placed that they enter into the necks of the cartridges and break the lead seals, whilst tight connections between the upper and lower parts are established by means of india-rubber washers. The upper crown is provided with a hose, S, fitted with mouthpiece and saliva-catcher; and the lower crown with a bag, H. The frame and cartridge are covered with a mantle, I, of non-conducting material. Cartridges containing ½ pound of peroxide will permit of the apparatus being used in irrespirable atmospheres for at least 45 minutes when the user walks quickly or works; and for 90 minutes or more, when the user keeps quiet or walks slowly.

FIG. 13.—PNEUMATOGEN: I. TYPE.

The whole apparatus is kept folded together in a tin protecting case ready for use. The weight of the apparatus is 2 pounds, and that of the tin 1 pound 4 ounces. The apparatus can be kept inside the tin for many years: an occasional examin-

ation of the indiarubber parts and the lead seals only being necessary.

To use the apparatus, the two parts of the frame are pushed vigorously together as shown in Fig. 14, whereby the cartridge is opened, the two joints made perfectly tight and the connection with the mouthpiece and the bag established. The

[redacted]

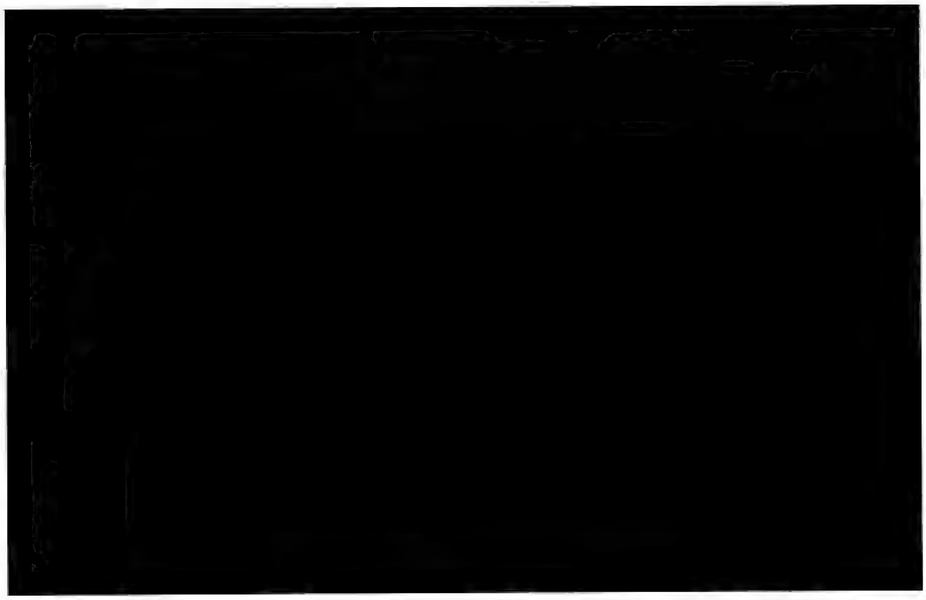
tained. From this box the air enters the bag, H, which is made of best Para indiarubber, and the air returns in the same way when exhalation takes place.

Cleaning and recharging of the apparatus is equally simple. As shown in Fig. 15, the insulating covering and frame is taken into two parts, and the exhausted cartridge is changed for a newly charged one.

FIG. 15.—PNEUMATOGEN: I. TYPE.

The excellent results obtained with the first type of this apparatus encouraged the inventors to design the second type. To enable the wearer to use the apparatus for longer periods when heavy work had to be carried out, it was found, for various reasons, that a simple increase of the dimensions of the first type of the pneumatogen did not give satisfactory results. Dr. Bamberger and Dr. Böck, therefore, designed the second type of their pneu-

matogen, in which three cartridges of the same dimensions and contents as in the first type are placed together side by side in a protecting case made of aluminium, together with a frame consisting substantially of two transverse tubes connected by a yoke. Both transverse tubes carry three perforating crowns for the three cartridges, Fig. 16. To the upper transverse tube are attached two flexible hoses carrying the mouthpiece, the saliva-catcher, and the nose-clamp, whilst the lower transverse tube is connected by an aluminium-tube with the breathing-bag, which is made in the form of a jacket as shown in Fig. 16. When using the apparatus the lead seals of the cartridges are perforated by turning the screw, R, whereby all the joints are hermetically closed in the same way as in the first type. The wearer then puts on the



of which the user is warned by the high resistance offered to breathing, the third box is put into action by pulling outward the handle G (Fig. 18), whereby a sliding tube inside the upper transverse tube effects a connection with the third cartridge.

The apparatus containing three cartridges, each filled with ½ pound of potassium-sodium peroxide, permits the user to remain in irrespirable gases for 120 minutes when heavy work is done by the wearer; 80 minutes are counted for work, and 40 for the retreat. With less work, the time of using increases to 3 or 4 hours.

FIG. 17.—PNEUMATOGEN: II. TYPE.

The same apparatus, provided with cartridges containing 10½ ounces (330 grammes), permits a comparatively longer breathing time, whilst the dimensions of the apparatus are only increased 1 inch in length. The weight of the complete apparatus provided with three cartridges, each containing ½ pound of peroxide, amounts to 8½ pounds, which is distributed over the breast and back.

It is evident that when the pneumatogen is brought into use the breathing-bags of both types are almost empty. It is therefore necessary to fill them with a quantity of air equal to that contained in the lungs before the apparatus is brought into action. In the first type this is effected by providing a spring frame inside the bag, so that when the latter is taken out of the tin, the bag inflates and fills itself with the necessary volume of air automatically.

The first tests made with the pneumatogen showed that at first the generation of oxygen from the peroxide is rather slow, as the reaction does not properly commence until a certain temperature is reached. During the first few minutes, therefore, the user must avoid any great exertion, but should breathe quietly, whilst sitting, standing or slowly walking.

With the second type of working apparatus, naturally the time, before the reaction of the peroxide becomes prompt and energetic, is comparatively longer. To avoid any waiting, and to enable the user to quickly begin to walk or carry out heavy work, it is advisable to fill the bag previously with a small quantity of oxygen (500 to 800 cubic inches). This is most simply done by the use of the apparatus shown in Fig. 19, which consists of a large receptacle, St_1, containing oxygen under high

[redacted]

A number of apparatus can be filled simultaneously by connecting them at the same time with the oxygen-cylinder.

If compressed oxygen is not available, a specially rapid oxygen-producer may be used, as shown in Fig. 20, in which oxygen is generated from potassium-sodium peroxide by the action of water. The oxygen enters through the tube, F, into the breathing-bag. The oxygen can also be introduced through the mouthpiece.

FIG. 19.—PNEUMATOGEN : II. TYPE : CHARGING THE BREATHING-BAG.

Although the temperature of the inhaled air in the pneumatogen is found by measurements to be fairly high, due to the heat generated by the chemical action, this does not interfere with the comfort of the user, owing to the almost completely dry state of the regenerated air. Consequently, in the pneumatogen the special cooling appliances found necessary in other forms of apparatus are dispensed with.

In the types of apparatus in which compressed oxygen is used, it is necessary to regulate the supply of oxygen so that it escapes in a constant and regular stream during the whole time that the apparatus is in use, whether the user is carrying out heavy work or whether he remains quiet. In the pneumatogen, the regulation of the oxygen-supply is automatic, so that the quantity of oxygen produced is proportional to the wearer's requirements. An increase in the quantity of oxygen required is always preceded

[redacted]

injector-valves, etc., which form an unavoidable supplement to an apparatus using compressed oxygen. If one considers the exceedingly great differences in pressure prevailing in the latter apparatus, it is evident that as the pressure of oxygen, amounting to over 1,700 pounds, has to be reduced to a few pounds by means of a finely made valve with minute holes, there is risk of danger even to the skilled and experienced user, and it is difficult to imagine how the auxiliary valves provided can decrease such danger, if by accident the supply of oxygen is cut off; as for instance, small particles of dust may be carried over by the oxygen, block the pressure-reducing valve, and so cut off the oxygen-supply. In such cases, the user, overcome by excitement through the increasing want of oxygen, may not be able to manipulate such auxiliary valves. Amongst others, Messrs. J. Mayer and Köhler,* of Austria, both mining engineers of great experience in the development of rescue-apparatus, have repeatedly referred to the danger entailed by the use of such valves. Of the various cases known to the writer, in which most serious consequences resulted from the failure of the valves, he would only refer to the sad case at Courrières, where, during the rescue-work, a member of the rescue-party using a Draeger apparatus lost his life. The man was found suffocated, with the helmet detached lying beside him; and, considering the whole circumstances of the accident, it seems probable that his death was caused through some failure of the valves.

FIG. 21.—NOSE-CLIP.

Referring to the use of nose-clips, the writer, without discussing the relative merits of helmets, masks or nose-clips, would state that the objection raised against nose-clips, that they fall off when the wearer perspires, has been overcome in the case

* "Über Rettungsapparate und deren Verwendung im Ostrau-Karwiner Reviere und über den Sauerstoffapparat System Wanz," by Mr. Johann Mayer, *Österreichische Zeitschrift für Berg- und Hüttenwesen*, 1904, vol. lii., pages 361, 379, 394, 410, 427, 618 and 633.

of the new pneumatogen nose-clip. This nose-clip (Fig. 21) is so constructed that it can be regulated to any form of nose, and by means of sticking plaster inside the clip, can be prevented from slipping off.

In order to give the members an idea of the most important results that Dr. Bamberger and Dr. Böck have attained by the construction of their pneumatogen, the writer will refer to the construction and development of those forms of modern rescue-apparatus which have been approved and adopted by the mining world.

The latest type of rescue-apparatus which Mr. W. E. Garforth described before The Institution of Mining Engineers last month is not included, as the writer has been unable to obtain the necessary information during the short time that he had to prepare this paper. He has also omitted the Fleuss apparatus as he has failed to ascertain whether in its present form it has been tested or adopted.

Figs. 2 to 10 (Plate II.) represent diagrammatic sketches of the principal forms of apparatus, all of which are based on the use of compressed oxygen and of various alkalis for absorbing carbonic acid. The illustrations show how the apparatus, from the plain and simple form of the pneumatophore, become more and more complex through the endeavour to bring them to a more perfect working state.

Fig. 2 (Plate II.) shows the original form of the pneumato-

fied by connecting the oxygen-supply pipe close to the mouthpiece, in order to supply fresh air to the user more readily, and by introducing a tube by which the exhaled air is more effectually conducted to the absorbing material. The carbonic-acid absorbing regenerator is considerably enlarged and an arrangement for cooling the exhaled air after regeneration, consisting of a metal pipe about 15 feet long, and placed round the oxygen-cylinders, is added.

The latest model of the Shamrock-Giersberg apparatus, the 1906 type, is shown in Fig. 9 (Plate II.), and differs from the previous type mainly in the addition of a special device for the absorption of moisture and caustic-soda dust, which was found necessary, because in many cases the cooling pipes and injector became choked by the moisture and dust carried over from the breathing-bag. This device consists of a pipe filled with kieselguhr (infusorial earth) and connected longitudinally with the lower horizontal pipe of the cooling arrangement. Two oxygen-cylinders of larger dimensions have been adopted. A device for warning the wearer when the oxygen-supply is running out has been added.

Regarding the Draeger apparatus, which more or less resembles the Giersberg and Shamrock-Giersberg types, the writer will only refer to the latest type, as shown in Fig. 10 (Plate II.). In this type, a special regenerator, in the shape of cartridges,

The writer has compared the various types of modern rescue-apparatus in the accompanying table, in which the figures quoted are taken from data and results obtained in practice. The results of the comparisons made in the table are briefly as follows:— The types of apparatus using compressed oxygen are not absolutely reliable, being complicated in construction and fitted with numerous valves and joints, some of which are subject to high pressure; the pneumatogen, however, is free from such drawbacks. The oxygen is generated in the pneumatogen, according to requirements, and the supply is reliable. The pneumatogen of the second type weighs about one fourth, and of the first type about one-eighteenth of the other forms of apparatus. The warning device is simple and effective. The price of the pneumatogen of the first type is considerably less than half that of the second type, and only one-ninth of that of the Shamrock apparatus. The cost of using the pneumatogen is slightly higher than that of other forms. This, however, will be reduced so soon as the potassium-sodium peroxide is manufactured on a large scale, and this can be looked for at an early date. It should also be taken into consideration that with the Giersberg, Shamrock and Draeger apparatus, considerable wear-and-tear, entailing costly repairs, are unavoidable, as the valves and sensitive metal parts are much affected by oxidation, caustic potash and oxygen.

None of the parts of the pneumatogen are subjected to high pressure, and the length of connecting piping is reduced to 6 inches. The whole distance travelled by the generated oxygen and the exhaled air in process of regeneration, is only 18 to 20 inches.

It has been stated that the use of alkaline peroxides in the pneumatogen might give rise to the ignition of combustible materials, but such a danger is avoided by keeping the peroxide in hermetically sealed cases, when stored ready for use in the apparatus. It may be pointed out on the other hand that the danger attending the handling of oxygen, compressed under the enormous pressure of more than 1,700 pounds per square inch, has often been referred to by various writers.*

* "Vorrichtungen zum Nachfüllen der Sauerstoff-Flaschen bei den Rettungsapparaten," by Mr. Johann Mayer, *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 1899, vol. xlvii., pages 409 and 427.

TABLE I.—SUMMARY OF THE DETAILS OF CONSTRUCTION OF THE VARIOUS TYPES
STATION OF THE WESTPHALIAN MINE-

No.	Type of Apparatus.	Draeger Helmet.	Giersberg Helmet.
1	Time during which the apparatus can be used.	2 hours, including heavy working.	Apparatus in present form unsuitable for long work in irrespirable gases.*
2	Reliability.	Not reliable, owing to reducing valves.	Not reliable, owing to reducing valves.
3	Valves.	1 reducing, 1 injector, 2 discharge, 2 oxygen admission and shut-off valves, 2 mica-valves in breathing tubes and 1 manometer.	1 reducing, 1 injector, 2 discharge, 2 oxygen admission and shut-off valves and manometer.
4	Oxygen-cylinders.	2 cylinders.	2 cylinders.
5	Cooling of exhaled air.	Surface-cooler.	Tube-cooler.
6	Regulation of oxygen-supply.	Constant supply; for regulating, reducing, and discharge, valve used.	Constant supply; for regulating, reducing and discharge, valve used.
7	Device for warning, [redacted]	Automatic acoustic [redacted]	User has to work to his [redacted]

[redacted]

OF RESCUE-APPARATUS TESTED AT THE RESCUE-APPARATUS TESTING AND TRAINING OWNERS' ASSOCIATION AT BOCHUM.

No.	Shamrock-Giersberg.	Pneumatogen II.	Pneumatogen I.
1	2 hours, including heavy working under the same conditions as the Draeger.	2 hours, including heavy working under the same conditions as the two previous apparatus.	80 minutes, including almost constant work (fixing pipes, etc.)
2	Not reliable, owing to reducing valves.	Absolutely reliable, because the working does not depend on mechanical appliances. Smallest diameter of inlets and outlets, ¾ inch.	Same as pneumatogen II.
3	1 reducing, 1 injector, 2 discharge, 1 auxiliary, 2 oxygen admission and shut-off valves and 1 manometer.	No valves.	No valves.
4	2 cylinders.	No cylinders.	No cylinders.
5	Tube-cooler with moisture and caustic soda-dust absorber.	No cooler required.	No cooler required.
6	Constant supply; for regulating, reducing and discharge, valve used.	Oxygen generated automatically, according to consumption. No valves required.	Same as pneumatogen II.
7	Same as the Draeger.	One cartridge reserved for retreat.	(For self-rescue purposes.)
8	Injector and tube.	No air-circulation device required.	No air-circulation device required.
9	35½ lbs.	8½ lbs.	2 lbs.
10	On the back, the whole oxygen-apparatus with numerous valve-joints, and one large breathing-bag in front.	On the back, perfectly smooth as a jacket. Regenerator in front, to hand and in sight. Weight divided equally between the chest and the back.	The whole apparatus with the breathing-bag is carried on the chest.
11	£19 17s. 6d.	£7 10s. 0d.	£2 5s. 0d.
12	5s. 0d.	6s. 10d.*	3s. 4d.

* Cartridges for retreat are not required for training purposes.

The writer would especially mention that the pneumatogen has long since passed out of the experimental stage, and has been adopted extensively in the mines of Austria and other countries. It was used at the Courrières mines, although, unfortunately, this was only possible after the German rescue-party had left.

The practical value of the first type of the pneumatogen, which is essentially for self-rescue, has yet to be proved. It affords, however, a most valuable apparatus, enabling men to pass through noxious gases in mines as well as in other industrial establishments; whilst, owing to its exceedingly small weight (2 pounds), it may be carried by rescue-parties, using the larger working-apparatus, and also used by the rescued persons to pass through those parts and roadways of the mine that are filled with irrespirable gases.

In conclusion, the writer would draw the attention of the members to the recent valuable and interesting report by Prof. H. Grahn, who is in charge of the rescue-training and testing station of the Westphalian Mine-owners' Association, of the Mining School at Bochum, on "Tests with Rescue-apparatus and its Improvements."* Prof. Grahn summarizes the results of the tests as follows:—

Regarding the forms of oxygen-apparatus, the two types of the Draeger apparatus, and the altered form of apparatus of the Oxygen Works at Berlin (Shamrock type) fitted with reducing valves and easily accessible purifying tubes, have proved quite practicable. The Giersberg helmet-apparatus, in its present form, is unsuit-

[redacted]

summer at the Bochum Mining School, and that the collieries in Westphalia, almost without exception, have agreed to take part in them.

The great interest that is being taken in this country in rescue-installations is due in no small degree to the members of this Institute, amongst whom the writer would mention Mr. W. E. Garforth, Mr. W. Blake Walker and Mr. M. H. Habershon; and he hopes that by calling attention to the pneumatogen to have been of some service in the noble work of rescue.

Mr. T. W. H. Mitchell said that the pneumatogen was light, but he was not sure that it was lighter than the apparatus which Mr. Garforth shewed them in London. He felt, however, that it had some small advantage over the other apparatus inasmuch as it had the third cylinder, and a man always knew that, when the two others were done, it was time that he stopped work and returned to fresh air again. He moved a vote of thanks to Mr. Cremer for his paper.

Mr. W. Walker (H.M. Inspector of Mines), in seconding the resolution, said that such papers helped the object that they had in view of discovering the best apparatus for rescue-work. He had had the opportunity of seeing both types of pneumatogen in use at the rescue-station at Tankersley. A man wore the self-rescue type, for 26 minutes, doing light work, such as building a stopping with bricks, and at the end of that time came out of the gallery because the apparatus had become so hot that he thought something was wrong with it. On examination, it was found that the paper round the tin containing the potassium-sodium peroxide was singed and that there was a smell of burning from the apparatus itself. The second type was worn by a man for 42 minutes doing work which required some energy, such as putting up a brattice and sawing hard wood, and he was asked to come out because they could not wait any longer. The apparatus was hot, and the wearer complained of a dry and hot feeling in his throat. Mr. J. McMahon had had it on, and he felt the same thing. The nose-clip, which Mr. Cremer advised, was very efficacious, it could only be got off at the expense of the skin on the man's nose. The great value of this apparatus was its lightness.

If it could be made absolutely reliable, and the defects as to heat remedied, it would be a very useful apparatus.

Mr. J. McMahon said that he had worn the pneumatogen, and had had a good deal of experience with the Giersberg apparatus, and the only defect that he could detect in the former apparatus was the excessive heating. Breathing was simple and easy, and he could do laborious work when using it. If the heat-defect were remedied, the apparatus would be a very practicable one. There was no feeling of fatigue in wearing it, as the weight was only 8 pounds; and this was a great advantage when compared with the weight of the other apparatus, 32 to 37 pounds.

Mr. M. H. Habershon asked Mr. Cremer whether any information had been obtained as to the purity of the oxygen generated by the chemical reaction that he had described.

. Prof. G. R. Thompson said that he had estimated the cost of oxygen prepared by Mr. Cremer's process; and it was 1s. 6d. per cubic foot, as compared with 3d. per cubic foot, the price of the oxygen ordinarily supplied, but the system provided at the same time the absorbent for the carbon dioxide generated in breathing. He agreed that the expense of generating this oxygen was chiefly due to the small demand for potassium-sodium peroxide and that would seem to be the case, for sodium peroxide, a somewhat similar compound used extensively in dyeing, was only a third or a quarter of the cost. If the cost [redacted]

months they would have, from one source or another, a better form of apparatus than those they had been using.

The resolution was carried.

Mr. CREMER said that oxygen produced from these chemicals was absolutely pure, whilst the compressed oxygen supplied by various manufacturers was not always absolutely pure. There was no doubt that the temperature, raised by the oxygen generation, was higher than in other apparatus; but, at the same time, the air was considerably drier, and, therefore, the heat should not be felt so much as in other apparatus, with which it was always necessary to use a special cooling arrangement. The temperature was easily reduced by adopting an arrangement which would cause the air to circulate through an additional pipe attached to the breathing-bag. By introducing two mica-valves, the air could be forced to circulate in the pipe, and this would decrease the temperature enormously. One of the great claims, however, for the pneumatogen was its simplicity, and as soon as the mica-valves were adopted, that simplicity would, to a certain extent, be destroyed. The advantage gained by the lower temperature was not, in the opinion of the inventors, worth the addition of two mica-valves; and in his (Mr. Cremer's) opinion the wearer would, with experience, get accustomed to the slightly higher temperature. Table I. showed the exact costs of using the various apparatus. Prof. Thompson had not considered the cost of the alkalis used in the other apparatus.

The discussion was adjourned.

LOW MOOR IRON-WORKS.

Low Moor iron is made from ironstone, worked in conjunction with the Black Bed coal-seam, which lies just below it; and the coke used for smelting the ironstone is made from the Better Bed coal-seam, which is found 120 feet below the Black Bed seam.

The blast-furnace plant consists of two furnaces of the following dimensions:—(1) Height, 70 feet; bosh, 18 feet; hearth, 8 feet; and throat, 15 feet. (2) Height, 70 feet; bosh, 14 feet;

hearth, 7 feet; and throat, 11½ feet. These furnaces are capable of producing about 600 tons of cold-blast pig-iron per week. The vertical direct acting blowing-engine has a steam-cylinder, 40 inches in diameter; an air-cylinder, 84 inches in diameter, and a stroke of 5 feet; the steam-pressure is 80 pounds per square inch; and the pressure of the blast, up to 6 pounds per square inch. This engine has been duplicated to meet emergencies.

Electrical Installation.—This installation comprizes one combined unit consisting of a cross-compound horizontal condensing engine, with double-beat drop-valves for the high-pressure cylinder and Corliss valves on the low-pressure cylinder. When running at 96 revolutions per minute with a boiler-pressure of 160 pounds per square inch, it will develop 550 indicated horsepower. The engine is coupled to a three-phase alternator of 350 kilowatts normal capacity. The power is transmitted to a distance of ½ mile at a pressure of 1,000 to 1,050 volts. The current drives thirty motors ranging from 3½ to 50 brake-horsepower, and a total of 479 brake-horsepower.

The motors, with the exception of one of 3½ brake-horsepower and the crane-motors, are placed direct on the 1,000 volts system. A suitable static transformer-plant gives a 250 volts system for the above exception and also for lighting.

The lighting installation consists of approximately 550 incandescent lights and 80 arc lights.

[redacted]

tuyères and are capable of being worked with a charge of 30 cwts. of pig-iron. In the puddling furnaces, a weight of about 3 cwts. of refined iron is charged per heat.

The steam-hammers, which have replaced the old tilt-hammers and helves, consist of 3 tons, 4 tons, 7 tons and 8 tons hammers. The plate rolling-mills consist of (1) a 24 inches plate-mill with 7½ feet rolls, driven by two 60 horsepower low-pressure beam condensing engines having two cylinders 41 inches in diameter and 7 feet stroke, attached to the mill and fitted with reversing gear; and (2) a large plate-mill driven by a horizontal high-pressure reversing engine with two cylinders, 50 inches in diameter and 5 feet stroke, working at 50 revolutions per minute, under a steam-pressure of 60 pounds per square inch. The plate rolls are 32 inches in diameter and 11 feet long.

The testing-house contains a 50 tons single-lever testing-machine, fitted with a hydraulic straining cylinder, 10⅝ inches in diameter and 6 inches stroke, working at a pressure of 1,500 pounds per square inch.

The following paper was read and discussed at the General Meeting held in Sheffield on April 10th, 1906:—

AN ACCOUNT OF SINKING AND TUBBING AT METHLEY JUNCTION COLLIERY, WITH A DESCRIPTION OF A CAST-IRON DAM TO RESIST AN OUTBURST OF WATER.

By ISAAC HODGES.

I. Sinking and Tubbing.

The Methley Junction colliery is situate near the river Calder, about 8 miles south-east of Leeds. About the year 1850, a downcast shaft, 11 feet in diameter and an upcast shaft, 10 feet 8 inches in diameter, was sunk to the Haigh Moor seam. Great difficulties were encountered in the sinking, owing to bad ground and large quantities of water, due to the fact that the shafts passed through the Methley fault, having a very wide fracture. This fault crossed the river Calder, some 1,800 feet away, and conveyed a feeder from the river to the pits (Fig. 1, Plate III.). Five lifts, 12 inches in diameter and of $3\frac{1}{2}$ feet stroke, were used during the sinkings, dealing with a feeder of upwards of 100,000 gallons per hour, which was considered a large quantity of water for those days. Each shaft was tubbed from 60 feet to a little over [redacted]

and dumb-drifts, stables and roadways, with the result that the crush on the weakened pillar caused difficulties with the tubbing in the upcast shaft (Fig. 4, Plate III.).

An attempt was made to strengthen the shaft-pillar by building strong stone packs of dressed-stone blocks at great expense, but this was not very successful. The ventilation being produced by a furnace, the leaky tubbing of the upcast shaft was much deteriorated by sulphur-fumes in conjunction with the water, the sheathing and plugs being also partly burned out: so much so, that about 1872 it was decided that the tubbing in the upcast shaft had become unsafe. That shaft was then re-lined with tubbing, the new crib being attached to the bottom-crib of the old tubbing by projections into the pigeon-holes of the old crib (Figs. 5 and 6, Plate IV.). This reduced the diameter of the pit from 10 feet 8 inches to 9 feet 6 inches, and 10 feet lengths of bell-mouthed extensions were built at the top and bottom of the lining to get back to the original diameter. The re-lining was done by damping-down the furnace at week-ends, the old tubbing being scraped, re-wedged and re-plugged, and the new tubbing built. The heat and fumes, however, largely destroyed the sheathing of the new tubbing before the next week-end came round to build another length; and, when the new tubbing was completed and the furnace finally put out, the contraction, together with the defective sheathing and plugs, caused considerable quantities of water to escape. The foundation crib-bed of this re-lining was also not a good one, and some water escaped therefrom; and, gradually increasing in quantity, it became a serious matter about 1897, when the author of this paper came to the colliery.

The decision having been taken to work the Silkstone and Beeston coal-seams in that district from Whitwood, by rise drifts through the Methley fault, it was resolved to sink one of the Methley Junction pits to those seams for ventilation and power purposes, and for winding men. Before coming to a decision as to which pit should be sunk, the writer made a careful examination of the tubbing of each shaft. He found that the tubbing of the upcast shaft was sound, but the foundation-crib was leaky, with a gradually increasing quantity of water then reaching about 6,000 gallons per hour; the tubbing in the downcast shaft was

quite dry, the foundation-crib was tight, and a few test-holes made in that tubbing shewed strengths and pressures as recorded in Table I.

TABLE I.—THICKNESSES OF TUBBING AND PRESSURES OF WATER IN THE DOWNCAST SHAFT.

Depths from Top of Tubbing.	Thicknesses of Tubbing.	Actual Pressures of Water per Square Inch.	Calculated Pressures of Water per Square Inch.
Feet. Inches.	Inches.	Pounds.	Pounds.
Upper Section—			
29 6	$1\frac{1}{4}$	14	13
60 5	$\frac{7}{8}$	27	27
91 5	$1\frac{1}{4}$	40	40
122 5	$\frac{7}{8}$	55	53
Lower Section—			
152 5	$1\frac{1}{4}$	20	66
183 5	$1\frac{7}{16}$	$32\frac{1}{2}$	80
214 5	$1\frac{1}{2}$	45	92

The test-holes were made by a fine ratchet-drill boring a hole, $\frac{3}{16}$ inch in diameter, and carrying a graduated scale, which could be read off the instant that water was reached. The tests were considered fairly satisfactory, and it was resolved to sink the downcast shaft to the lower seams. Some months afterwards, the writer, pondering over the differences of the test-thicknesses of the tubbing, decided to try every segment of a few of the rings at the base of the upper section, in order to see how far they [redacted]

unsafe, and particularly so as the metal was very much deteriorated in quality. From the section of the shaft, it will be seen that the first ring, J, above the crib of the upper section of tubbing was inside-flanged; and this was found to be backed with cement, forming a barrier between the two sections of water, which explains the different series of pressures (Fig. 2, Plate III.). The second ring was outside-flanged, and carried a pipe, I, 6 inches in diameter, having a blank flange, 12 inches in diameter, secured by four studs, $\frac{3}{4}$ inch in diameter, which had been used to let out the water behind the tubbing, so as to ease the pressure during the tubbing-operations and to aid in fixing the segments. This flanged pipe caused considerable anxiety, as the studs had been badly eaten away by water trickling down the shaft, in the earlier days: the threads had quite disappeared, and the nuts were much reduced in size and strength.

An attempt was now made to ascertain the quantity of water that had to be dealt with. The water in the lower section of the tubbing was quickly run off, and was found to be only a pocket of water, with a very small feeder. In the upper section, the tubbing segments were unplugged, until the water-level was reached, and this level was found to be about that of the river Calder: the water rising and falling approximately with that in the river. To ascertain the quantity of water passing from the river, a house was made in the side of the shaft, at the top of the tubbing, in which a Tangye pump was fixed, pumping from a semicircular cistern, slung in the shaft between the back of the conductors and the tubbing (Fig. 29, Plate VI.). This cistern was fed by twenty-five indiarubber pipes passing round the shaft, out of reach of the winding cages, and coupled to the plug-holes in the segments of tubbing. Continuous pumping of about 10,000 gallons per hour for eight weeks had little effect on the water-level: the pumping only reducing the pressure by about 3 pounds per square inch. These experiments proving that the volume of water was a large one, it was decided not to attempt further to pump the feeder, but to line the shaft with stronger tubbing.

Before deciding upon the internal diameter of this re-lining, careful measurements were taken of each ring of the old tubbing

from a centre-line, and particularly of the position of the flanged pipe; and, from the plotting-plan of these rings, a new centre-line was determined. Allowing for tubbing with flanges $3\frac{7}{8}$ inches wide and lips $\frac{7}{8}$ inch wide, it was found that an internal diameter of 9 feet 11 inches could be obtained. To reach this reduced diameter, the writer decided to adopt three tapered foundation-cribs, the bottom one, 24 inches wide, tapering from 10 feet 11 inches to 10 feet 7 inches; the second one, 20 inches wide, tapering from 10 feet 7 inches to 10 feet 3 inches; and the third one, 20 inches wide, tapering from 10 feet 3 inches to 9 feet 11 inches; with a special base ring, 20 inches wide on the bottom flange, diminishing to $3\frac{7}{8}$ inches on the top flange to carry the tubbing (Figs. 7, 8, 9, 10 and 11, Plate IV.). The cribs were made of metal $1\frac{1}{2}$ inches thick, and were each 5 inches deep, the base ring of metal $1\frac{1}{2}$ inches thick and 2 feet 6 inches deep, and the tubbing was 2 feet 6 inches deep and $1\frac{3}{8}$ inches thick, reducing by steps of $\frac{1}{8}$ inch to $\frac{3}{4}$ inch. The number of segments used were as follow: 128, $1\frac{3}{8}$ inches thick; 128, $1\frac{1}{4}$ inches thick; 128, $1\frac{1}{8}$ inches thick; 128, 1 inch thick; 128, $\frac{7}{8}$ inch thick; and 176, $\frac{3}{4}$ inch thick (Fig. 2, Plate III.). The cribs, base ring and tubbing plates had eight segments to a ring, and all of them were coated with Dr. Angus Smith's composition. The tubbing plates were strongly bracketted, and had three bolt-holes in each flange, so as to be bolted together at the surface and sent down the pit in rings. Each segment had the thickness cast on the [redacted]

not find a good foundation until a depth of 318 feet, necessitating the laying of the new crib-bed within 120 feet of the coal-seam. A sound bed was made there by running in granite-concrete, composed of three parts of 1 inch granite-chippings to one of cement, floated to a level surface, and allowed to stand for 12 hours. The foundation-crib was placed in position, dowelled and securely wedged, and the two tapered cribs and the special base ring were placed thereon. The cribs and ring were further strengthened by eight oak struts, 12 inches square, tightly wedged to strong ledges on the shaft-sides, and the whole was run in solid with rough granite-concrete (5 to 1); a block of about 50 tons being thus made.

The tubbing segments were then built in position, the annular space between the old and the new tubbing being filled with concrete so long as there was space. On reaching the middle crib of the old tubbing, and opposite to the inside flanged ring, J, that had been found to be backed with concrete, the new tubbing was tightly wedged and made solid to form a bed; and a 10 feet length of concrete was formed to act as a diaphragm between the two sections of water, so as to keep the full pressure of water from the lower length of tubbing, whenever the upper section of the old tubbing should burst (Fig. 2, Plate III.).

Up to this point, the tubbing had been sent down the pit in segments, owing to the risk of conveying complete rings past the dangerous flanged pipe; but, from that point upwards, the segments were built into rings at the surface and sent down by a special tool. A double drawbridge was arranged at the surface, one drawbridge being placed on each side of the pit (Figs. 12 and 13, Plate IV.). The upper bridge had a turntable built in the centre: the segments being carried by blocks running on overhead girders to the turntable, the sheathing was attached, the turntable was revolved, and the segments were bolted together until a complete ring was formed. The rings weighed 3½ to 2½ tons each. The lower bridge on the opposite side of the shaft carried two projecting girders to span the shaft, the girders sliding into cast-iron rests to hold them secure. This bridge was weighted to counterbalance the weight of the overhanging girders, and was pulled into position by a barrel-winch, fixed on the bridge, hauling on a stationary chain anchored at both ends. The lower bridge was

hauled with the girders over the shaft, the upper bridge was then run on so as to be in position for the crab-rope to take up the ring, and when this was lifted the upper bridge was drawn away on one side of the pit and the lower bridge, with the girders attached, on the other side, leaving the shaft clear. The tool for lowering the tubbing was a cross, hung on chains, made of two bands of wrought iron, 3½ inches wide and ¾ inch thick, riveted together and having four sliding projections, 1 inch in diameter, to fit into the plug-holes of the tubbing (Figs. 14, 15, 16 and 17, Plates IV. and V.). These projections could slide about 5 inches, and, whilst carrying the rings, were held securely in position by cotter-bolts. On the projections being withdrawn, they swivelled on a carrying bolt and hung vertically, whilst re-ascending the shaft. For safety, the workmen were withdrawn from the shaft for each ring, the crab-rope lowered the ring of tubbing, which guided itself down the shaft, and the workmen followed on the winding-rope in a kibble and guided the ring into position. On the workmen reaching the scaffold, the crab-rope was slackened, the cotter-bolts in the special tool were taken out, the projections slid back, and the tool was sent back to the surface on the crab-rope. The workmen then sent the empty kibble to the surface, and, on receiving the empty winding-rope, attached it to the scaffold and lifted it the height of a ring, secured the scaffold by pushing the bolts into the plug-holes of the tubbing, then disconnected the winding-rope, sent it to the surface for the kibble again, and, after [redacted]

On the top of the tubbing, a walling crib was fixed, and new walling, 10 feet in diameter, was built to the surface: the old pump-house being filled with earth.

The wedging of the tubbing was then commenced from the bottom, and was carried lightly throughout the whole length: to be more tightly wedged afterwards, as occasion required.

The decreased diameter of the shaft prevented the winding cages from being used again; and, in place of single-decked cages, carrying tubs side by side, two-decked cages having a single tub on each deck were designed, each cage running on three wire-rope conductors (Figs. 18 and 19, Plate V.).* As conductor-weights, hanging in the sump, would have been a possible danger to the sinkers below, it was decided to anchor the conductors to the safety-scaffold, described hereafter, and weight the conductors in the head-gear. To this end, levers carrying quadrants, to which the conductors were attached, were provided, and the levers were weighted sufficiently to take up the slack rope (Figs. 20, 21, 22, 23, 24 and 25, Plate V.). Very little time was required to take a fresh purchase, whenever the levers had descended so much as to give too little margin for expansion during warmer days. The steam and rising-main pipes were re-changed from the upcast to the downcast shaft, and an additional exhaust-steam main was put in to keep the free steam out of the upcast shaft.

Whilst designs were being prepared, the tubbing manufactured, and arrangements made for putting it into position, the sinking of the shaft was commenced. The sump was widened from 10 feet to 11 feet in diameter, by means of a kibble slung under the winding cages, the brickwork being built in cement to hold back the water from the old culverts. A staple-pit was sunk, 81 feet distant from the shaft, for a depth of 48 feet until favourable strata were reached; and then an under-level drift, on a slightly rising gradient and made sufficiently wide for empty and full roads, was driven to meet the shaft, which by that time had been deepened to that depth

* The references to Figs. 18 and 19 are as follows: A, rising main, 6 inches in diameter; B, rising main, 6 inches in diameter; C, steam-pipe, 6 inches in diameter; D, rising main, 7 inches in diameter; E, exhaust-steam main, 5 inches in diameter; F, gas-pipe, 2 inches in diameter; G, single-decked cage; H, two-decked cage; *a*, wood conductors; and *b*, wire-rope conductors.

(Fig. 4, Plate III.). The staple-pit was fitted with a steam-winch and cage to fit the ordinary pit-tub. In the main shaft, in addition to the balks carrying the keps and the sump-balks carrying the cages, a safety-scaffold made of close fitting memel, 12 inches square, was built, and covered with a thickness of 3 feet of clay, E (Figs. 26, 27 and 28, Plate VI.).

As the sinking-rope could not run in the centre of the shaft, owing to the winding-cages running in wood conductors having only 2 or 3 inches of margin at the meeting, the sinking rope was run down the side of the shaft and brought into the centre again below the safety-scaffold (Figs 26 and 27, Plate VI.). The angle of deflection of the rope was 130 degrees, running on pulleys, 2 feet in diameter, having flanges sufficiently wide to pass the winding-rope capel, set at centres about 5 feet apart; and, below the bottom pulley, a frame was fixed, and a detaching hook-plate was provided. The sinking-rope was boxed down the side of the shaft and through the safety-scaffold, and the boxes were made large enough to allow of the rope-capel passing through in case of overwinding and detaching. Although, with a geared sinking-engine, overwinding appeared very improbable, this actually occurred during the sinking: the winding-engineman, forgetting himself, over-wound at full speed, the kibble was detached, and the rope and capel passed through the boxes. The rope was lowered, replaced on the pulleys, and the capel re-connected to the kibble with a stoppage of only 2 hours.

[redacted]

seam, driving a fan, $2\frac{1}{2}$ feet in diameter, running at about 1,400 revolutions per minute, and forcing the air down ventilation-boxes, 14 inches square, passing through the safety-scaffold (Figs. 27 and 28, Plate VI.).

When the sinking had reached a depth of about 480 feet, and was within about 60 feet of the Silkstone seam, the working was discontinued, owing to the danger that, should an outburst occur in the defective tubbing and the shaft be connected with the Silkstone seam, the whole of the Whitwood pits would be flooded (Fig. 29, Plate VI.). When the re-lining had been completed, and the shaft thus made secure, sinking was again commenced; and, on the Silkstone seam being reached, a connection was made to the rise drift, which had meantime been driven through the Methley fault.

To provide ventilation for the opening-out of the Silkstone seam it was necessary that the new shaft should be an upcast; and, to allow of this, the under-drift below the Haigh Moor seam was continued beyond the shaft to a point beneath the main return-airway of that seam (Fig. 4, Plate III.). Another staple pit was then sunk to connect the under-drift with this return-airway, by which the ventilation proceeded, and forward through the dumb-drift to the upcast shaft. Doors were placed in that portion of the under-drift which connected with the winding staple, and the safety-scaffold formed a seal between the downcast portion of the shaft from the surface and the upcast portion from the Silkstone seam. The further depth of sinking of about 240 feet to the Beeston seam was banked at the level of the Silkstone seam, and the greater portion of the sinking dirt was stowed in the opening-out workings of that seam, the remainder passing down the drift and out to the surface at the Whitwood Silkstone pit.

II.—Cast-iron Dam in the Upcast Shaft.

Tests made of the tubbing in the upcast shaft proved that the segments were safe. In ninety-two rings of eight segments each, 736 tests were made, giving a minimum thickness of 1 inch with a maximum thickness of $1\frac{3}{4}$ inches. A scheme was then considered for underpinning the leaky foundation-crib, with a view to stopping the flow of water, which had now increased

to about 10,000 gallons per hour. Whilst those concerned were thinking of this, a sudden outburst of four or five times the volume of water occurred, bringing a large quantity of dirt, which filled the sump at the bottom of the upcast shaft, clogged the pump suction-pipes at the level of the Haigh Moor seam, and, running down the other shaft, flooded the Beeston seam. Inspection shewed that the rock, H, immediately underlying the foundation-crib, and for about one-third of the circumference of the shaft, had been pushed into the pit for about 18 inches, reducing the diameter of the shaft from 10 feet 8 inches to 9 feet (Fig. 3, Plate III.). This released some of the segments of the foundation-crib, and the tubbing shewed signs of giving way. Temporary steel skeleton-cribs were at once got into position so as to prevent the side of the shaft from being completely pushed in and thus set the tubbing free to fall; and seven stout oak cribs, of varying diameters to suit the reduced sizes of the pit, were afterwards placed in position, and tight wedges were driven between the crib and the shaft-sides to make it quite secure. The rushes of water came intermittently, the dirt dammed the water-course temporarily, until the head increased sufficiently to bring dirt and water together in large volumes. A third pump was rapidly installed, coupled to the existing steam-pipe, and fitted with a new suction-pipe to a temporary sump, and with a new rising-main, 7 inches in diameter and 450 feet long, to the surface: this work being completed within 36 hours. During the same period, the suction-pipes of the other two pumps were disconnected

of note that the 20,000 gallons of water per hour was pumped from this cistern, having only a capacity of 1,500 gallons, for twelve months without any overflowing.

The quantity of water, with an ever-present fear of further increase should the channel from the river become enlarged, coupled with the very bad state of the shaft, which prevented an attempt to tub off a further section, decided the company to close the shaft with a permanent dam. In designing the dam, two ideas presented themselves, a cast-iron dam in the shape of a dome with a horizontal base, or a wood dam built of vertical logs tapered to form a circular wedge. The wood dam, with, say, a thickness of 8 or 10 feet, gave a largely increased surface with which to make a water-tight joint, but it had the disadvantage of being perishable and somewhat difficult to build. The difficulty of using this kind of dam was further increased, as the writer knew that the sides of the shaft must be weak and tender: consequently it would be difficult to form an accurate taper in the broken horizontal strata, and it was impossible to say beforehand what area of ground must be extracted before solid ground would be reached. It was also of considerable importance that no further time than was absolutely necessary should be taken up in doing the work, not only on account of the risk of the mining operations increasing the outburst and flooding the collieries, but also on account of the safety of the workmen necessarily engaged in a dangerous kind of work. On the other hand, a cast-iron dam was rigid and unyielding, and a slight subsidence of one side, more than the other, might cause the horizontal base to become leaky.

After weighing the respective merits, the writer decided that a cast-iron dome with a horizontal base gave the best chance of success; but he designed the crib with an inclined taper of 40 degrees from the horizontal, so as to allow of some latitude in casting, as also in the fixing, and to keep the dam watertight, even should considerable subsidence occur, as the inclined surfaces might slide on each other. The shaft was 10 feet 8 inches in diameter, but the crib was made 12 feet in internal diameter, and 36 inches wide on the base, giving an external diameter of 18 feet (Figs. 30, 31, 32, 33 and 34, Plate VI.). On the internal

diameter of the crib was cast a lip, 6 inches wide and 1 inch thick, upon which wooden centres were built so as to hold up the dam during erection. The crib was made in ten segments, 2 inches thick, each segment containing two internal ribs, 2 inches thick, with a core-hole, 8 inches by 4 inches, in each division. The dome was formed of ten segments, owing to the reduced diameter of the shaft at the point of the outburst, each 2 inches thick with ribs 2 inches thick; and two of the segments had flanged holes, 9 inches in diameter. The flanges were provided with six holes for bolts, $1\frac{1}{8}$ inches in diameter, to secure pipes, 12 inches in diameter, that would be built through the concrete to allow of the 20,000 gallons of water per hour passing through them whilst fixing. The segments when jointed together left a hole, 9 inches in diameter, in the centre; and this was closed by a cast-iron plug having a heavy flange. All the segments were arranged for sheathing, $\frac{5}{16}$ inch thick, and the dome-segments had holes $1\frac{1}{8}$ inches in diameter, to bolt them together and to hold them steady whilst being covered with concrete. All the segments of the crib and of the dome were coated with Dr. Angus Smith's composition. The dam was erected in position and carefully fitted together on the surface, before being sent down the pit. The weight of the dam was as follows:—Crib, 12 tons $13\frac{3}{4}$ cwts.; dome, 12 tons $9\frac{3}{4}$ cwts.; a total of 25 tons $3\frac{1}{2}$ cwts.

The proposed closing of the upcast shaft compelled the downcast shaft to be changed into an upcast shaft throughout to the [redacted]

condition; the furnace, extinguished 35 years before, having destroyed most of the cribs, and allowed the unmortared walling, 4½ inches thick, to sag. The dam could not be placed at the bottom of the upcast pit, as the coal round the pit had been taken out. The porch had four openings, the pillars at the corners being made of dressed stone, and these pillars had long since split to pieces. A commencement was made 100 feet below the bottom of the foundation-crib of the bell-mouthed tubbing, where an old iron-crib formed some support for the walling; but, on the walling being taken away, it was found that the strata had perished so considerably by the heat and water that the sides commenced to run in (Fig. 3, Plate III.). The old crib was supported by driving in twelve iron plugs, 2 inches in diameter and 5½ feet long, and the running ground was held back by oak cribs, 12 inches by 4 inches, each carried on twelve wrought-iron plugs, 2 inches in diameter and 5 to 7 feet long, each crib being stepped back, about the width of itself, until stronger ground was reached. The diameter of the shaft, 10 feet 8 inches, was found to be widened to upwards of 15 feet before any solid ground was reached.

As the state of the walling and the tender nature of the ground caused some alarm to the workmen, the writer decided to line the length, IJ, of 100 feet of dangerous walling with cribs and backing deals (Fig. 3, Plate III.). Forty-seven cribs, 5 inches square, made of elm, larch and poplar, having butt joints and wrought-iron straps, 4 inches wide and ⅜ inch thick, each crib supported on eight punch-props, 18 inches long and 4 inches square, fastened with iron dogs, and close backed by 7,500 lineal feet of boards, 6 inches wide and 1½ inches thick, in 4 feet lengths, were rapidly built and jointed up to the oak cribs, 5 inches square, supporting the ground at the point of the outburst. This made the shaft entirely dry and perfectly safe, and the workmen were much comforted.

The shaft-walling was then stripped downwards in an endeavour to find a firm foundation. Nothing likely shewed itself, until at a depth of 370 feet, a width of 14 feet, with some strong ground, was found (Fig. 3, Plate III., and Fig. 29, Plate VI.). This had the disadvantage of being within 12 feet of a horizontal stone-drift from the Stanley Main seam into the pit. This drift

crossed the fault, and gave a chance to the water, after being dammed back in the shaft, to pass down the hade of the fault into the workings. About 3 feet lower was the mouth of the dumb-drift from the old furnace. An inspection of the dumb-drift shewed that the barrel arch was built of sound brickwork and in good condition; and it was decided to take the risk of the dumb-drift, to fill the stone-drift with concrete so as to prevent any chance of the strata giving way and releasing the fault-hade, and from the level of that drift to carry up the concrete solid in the shaft, so as to assist in making an artificial bed for carrying the dam. A wall, 3 feet thick, was built in the coal-heading just beyond the line of the fault, at a distance of about 72 feet from the shaft side, and the drift was filled back to the shaft with rough concrete, mixed with large blocks of Haigh Moor rock, and well rammed in layers: about 200 tons of concrete, mixed about 9 to 1, being used.

A light scaffold was built in the shaft, between the level of the stone-drift and the mouth of the dumb-drift, made of tramway-rails, 7 inches by 7 inches, side by side, with two pipes, 7 inches in diameter, built through it, to convey the water. The shaft was then filled to the level of the dam-bed, about 200 tons of concrete, made 7 to 1, being used, including an opening, 20 feet in diameter and 3 feet high, cut into the sides of the shaft so as to dovetail the block of concrete into the natural strata and to support the dam when the tramway-rails should have perished (Fig. 3, Plate III.).

wide, cast inside the crib, and the segments were built in detail and bolted together. An electric light was kept at the water-garland, at the contracted area of the shaft, and during the passage of the segments a man rode closely behind them to fend off the segments and to prevent damage to the cribs. When the dome was completed, the indiarubber pipes from the water-boxes were passed through the pipes, 9 inches in diameter, in the dome, the water running below the dome and finding an outlet through the pipes, 7 inches in diameter, built in the lower section of concrete. The dome was then cemented solid with granite-concrete, 3 to 1, to a height of 10 feet, pipes, 12 inches in diameter and 4½ feet long, being attached to the dome and built through the concrete. Slag-and-rubble concrete, mixed 5 to 1 to 7 to 1, was carried up a further height of 20 feet, making 30 feet in all, and a total weight of 350 tons of concrete above the dam, until the wood cribs supporting the old walling were reached. This large block had the advantage of taking off a great deal of the pressure from the dam, and of providing such a strength that should the cast-iron dam perish, at some future time, it may be expected to withhold the pressure of the strata and remain water-tight (Fig. 3, Plate III.).

On the concrete reaching the inside of the cribs and the backing deals, the writer decided that no further object would be gained by its extension, the main object of the concrete being to seal up any cracks above the dome that might lead downwards into the workings, and with the cribs and backing deals lining the shaft this object could no longer be attained. The total weight of concrete used in the shaft and drift was about 750 tons.

One of the pipes, 12 inches in diameter, was carried a length of 4½ feet higher than the other, and both of the water-boxes were jointed to this longer pipe, the shorter pipe being sealed by a heavy cast-iron plug, dropped down 26 feet to the bed on the dome, the pipe filled up with concrete, and a plug-flange bolted on the top. The concrete was then left to set for three days. It was calculated that the water would take 7 or 8 minutes to rise the 4½ feet extra length of pipe, and give that time for sealing up. A rope-ladder was fixed to the cribs, so that, should the winding arrangements fail at the critical time, a means of keeping pace with the water would be at hand. Five persons,

consisting of two workmen, the enginewright, the manager and the writer, went down the pit, and, on the indiarubber pipe being removed, the water commenced to fill the shaft rapidly. The heavy cast-iron plug to make the seal, suspended on a light chain, was then dropped down the pipe, but by some unfortunate circumstance it became wedged, and it was not until the water had reached the top of the pipe and some of the party were breast deep that a desperate pull loosened the plug and it was hauled out and taken back to the shops to be turned slightly less in diameter. The upper length of the pipe was then unbolted and canted on one side, and the water was cleared. At the second attempt, 8 hours later, the plug passed down the pipe easily (to effect a more secure joint, an indiarubber pad was fixed on the plug, and yarn and tallow were thrown on the top), and three kibbles of cement were rapidly emptied in the pipe; the water, however, rose rather more quickly than had been anticipated, and the blank flange could only be put on under water, and four out of six bolts secured, before the party were beaten out of the shaft. The water rose 33 feet per hour, reached to the bottom of the tubbing in 3 hours, and to the top of the tubbing at the river-water level in 8 hours later. The kibble brought out the men and tools, and all the cribs and deals were left in the pit (Fig. 3, Plate III.).

An inspection below the dam made immediately afterwards shewed that the plug and flange of the second pipe had not held quite securely, and that about 100 gallons of water per hour [redacted]

the surface, 1,335 tons; a total of 1,713 tons. The area of the crib is upwards of 140 square feet, giving a total weight of only 12 tons per square foot of area. The cost of the dam is shewn in detail in Table III.

From the day of entering the shaft to leaving it was exactly 5 weeks. In explanation of this time, it may be pleaded that considerably more work was encountered than had been estimated; and the time required for the setting of the large mass of concrete somewhat hindered operations.

TABLE III.—THE COST OF THE DAM.

Materials:				£	s.	d.	£	s.	d.
Cast-iron dam, sheathing and bolts				222	0	0			
Cast-iron pipes and bolts, above the dam ...				27	10	0			
Cast-iron pipes and bolts, below the dam ...				10	0	0			
Tramway-rails at Stanley Main drift				10	0	0			
Concrete: Cement	£168	0	0						
Dross	21	0	0						
Granite	26	0	0						
Sand	20	0	0						
Rough stones and bricks	50	0	0						
Bricks for the stopping in the drift	15	0	0						
				300	0	0			
Clay				70	0	0			
Cribs and backing-deals				102	0	0			
Sundries				8	10	0			
							750	0	0
Labour:									
Including surface-work; removing upcast head-gear and buildings; fixing new head-gear and drawbridge; erecting dam in position on the surface; fixing electric-light engine and cables; emptying cement, slag, bricks, etc.; preparing concrete; making and fixing cribs; making and sharpening tools; drying clothes; winding engineman and banksmen; underground labour taking out old brickwork; fixing cribs and backing-deals; building scaffolds; and laying concrete and dam							840	0	0
							£1,590	0	0

The charges incurred in pumping during the preceding twelve months are recorded in Table IV.; and this yearly charge was entirely obviated by the expenditure of £1,590 on the dam, with the additional advantage of extra security and safety. The wages are taken from the pay-sheets, and the fuel is calculated on the average monthly consumption of

500 tons burned at the boilers for the twelve months between the outburst and the damming of the water, less the average monthly tonnage burned during the twelve months afterwards.

TABLE IV.—CHARGES OF PUMPING FOR 12 MONTHS.

	£	s.	d.	£	s.	d.
Labour:						
Pumping-enginemen	214	0	0			
Extra winding-enginemen and firemen at week-ends	91	0	0			
Additional firemen on week-days	130	0	0			
				435	0	0
Fuel: 6,000 tons at 3s. per ton				900	0	0
Stores: say				40	0	0
Total				£1,375	0	0

The pumping-plant was, in some respects, extravagant of steam, but the most modern systems of pumping, with electricity charged at ⅜d. per Board of Trade unit, would not have reduced the charge below £1,000 per annum, as shewn by the estimate detailed in Table V.

TABLE V.—ESTIMATE OF THE COST OF PUMPING 20,000 GALLONS PER HOUR TO A HEIGHT OF 450 FEET, BY ELECTRICITY.

	£
60 horsepower, including slip and friction, at ⅜d. per Board of Trade unit	612
Redemption of capital at 5 per cent., and interest at 5 per cent. on the cost of pump, motor, cables and accessories	85
Labour, including winding engineman, banksmen and	

[redacted]

was almost negligible, a small high-speed engine and dynamo were fixed in the course of one afternoon, and they ran without trouble or definite attention during the whole of the period.

The writer has climbed up the shaft under the dam to inspect the general conditions, from time to time, and has noticed that large stalagmites of a calcareous deposit are being formed. Analyses shew that the trickle of water coming through the dam contains 113 grains of solid matter per gallon and that the stalagmites consist of calcium carbonate.

III.—Additional Tubbing in the Upcast Shaft: the Late Downcast Shaft.

As the writer expected that considerable quantities of water would have to be dealt with during the later life of the Haigh Moor seam, owing to the adjoining mines being abandoned, he decided to put the under-drift and the return-airway, used in sinking the shaft and to ventilate the lower seams, to the useful purpose of making a water-standage (Fig. 29, Plate VI.). The under-drift was lengthened by an addition of 375 feet, the whole water-standage being then equal to a capacity of 250,000 gallons. This stone-drift was driven by Champion and Hardy reciprocating drills at a cheap cost, a black oily shale, about 5 inches thick, allowing the drift to be kirved or holed. A pumping-enginehouse, formed in a thin coal-seam about half way up the winding staple, contained pumps driven by electricity and compressed air respectively.

The shaft-tubbing was designed sufficiently strong to carry tubbing at some future date to join up to the taper cribs, 135 feet above, put in the same shaft during 1900, when the Haigh Moor seam is worked out; the whole of the water in the Haigh Moor seam is thus expected to be kept from the lower seams without the expense of pumping.

In calculating the thicknesses of tubbing required, the writer investigated the formulæ stated by various experts; and he was much struck with their disparity, and with the small margin allowed for corrosion and general deterioration. For the Methley Junction shaft, the thicknesses of tubbing calculated according to formulæ approved by Messrs. J. J. Atkinson, G. C. Greenwell, W. Galloway and W. Tate are recorded in Table VI.;

and the writer has appended the thicknesses of tubbing that he used in the Methley Junction shaft for purposes of comparison. The experience with the earlier tubbing at this colliery had shewn that a considerable factor should be allowed for deterioration, both in thickness by active corrosion, internal and external, and for deterioration of the quality of the metal; and, particularly so, as a diminution of strength had serious consequences, quite out of proportion to the extra expense incurred in the first instance.

TABLE VI.—THICKNESSES OF TUBBING CALCULATED BY VARIOUS FORMULÆ.

Height of Tubbing.	Name of Expert.				Tubbing in Methley Junction Shaft.
	J. J. Atkinson. *	W. Galloway. †	G. C. Greenwell. ‡	W. Tate.	
Feet.	Inches.	Inches.	Inches.	Inches.	Inches.
			I.—Shaft: 10 Feet in Diameter.		
60	0·22	0·05	0·50	0·23	0·75
100	0·30	0·09	0·60	0·39	0·87
140	0·37	0·13	0·69	0·54	1·00
180	0·44	0·17	0·79	0·70	1·12
220	0·51	0·21	0·88	0·85	1·25
260	0·58	0·25	0·98	1·00	1·37
			II.—Shaft: 11 Feet in Diameter.		
300	0·70	0·32	1·15	1·27	1·50
340	0·80	0·36	1·26	1·45	1·62
380	0·90	0·41	1·36	1·62	1·75
420	1·00	0·45	1·46	1·79	1·87

* "The Strength of Tubbing in Shafts, etc.," by Mr. John J. Atkinson, *Trans. N. E. Inst.*, 1861, vol. ix., page 175.

[redacted]

rings formed of steel railway-rails, 85 pounds to the yard, strongly fish-plated together, 12½ feet in diameter, were built in concrete for a further height of 15 feet.

The foundation-crib, weighing 10 tons, was 11 feet in inside diameter, 30 inches wide, 6 inches high. It was made of metal, 2 inches thick, and was built in eight segments, each containing two internal ribs, 2 inches thick with core-holes, 5 inches in diameter, the segments being arranged for dowel-pins, 1¾ inches in diameter and 12 inches deep. On this was built a special base ring, weighing 8 tons, made in eight segments, 24 inches wide on the bottom flange and reducing to 4¾ inches wide on the top flange, 2 feet 6 inches deep, and made of metal 2 inches thick. The tubbing segments, eight to a ring, strongly bracketted, 1⅞ inches thick, 2 feet 6 inches deep, were backed with concrete to the sides of the shaft.

At the level of the water-standage, a bye-pass was made to connect the two drifts, a strong wall being built to carry the concrete behind the tubbing. A 40 feet length of tubbing was built, and it reached to the level of the new pumping-engine-house.

As 100,000 cubic feet of air per minute were required to pass up the shaft, during the tubbing operations, to ventilate the Silkstone workings, the scaffold had an opening, 6 feet in diameter, fenced off with a circular boiler-plate, 4 feet high. This opening also allowed of the kibble passing through the scaffold for the purposes of shaft-examination (Figs. 37 and 38, Plate VII.).

The writer trusts that this record of work done may be of interest to the members of this Institute, who may have similar work to carry out. He desires to express his thanks for the interest and enthusiasm shewn by the managers and officials of the company, without which the work could not have been so satisfactorily completed, and also to the friends who assisted with advice during the progress of the operations.

Mr. T. W. H. Mitchell, in proposing a vote of thanks to Mr. Hodges, for his paper, expressed the appreciation of the members for the great trouble that he had taken in preparing the accompanying illustrations.

Mr. W. G. Phillips, in seconding the vote of thanks, commented upon the comparatively small amount that Mr. Hodges had spent, in order to effect a saving of about £1,400 a year.

Mr. E. W. Thirkell, in congratulating Mr. Hodges upon his excellent paper, said that in matters of that kind it was not always a question of saving expense, but it might be a question of saving a pit, and Mr. Hodges had shewn an amount of pluck and grit which the members were bound to admire.

Mr. M. Deacon said that if members would take the time and trouble to write papers of that practical character, the value of the *Transactions* would be greater, and the Institutes would shew to much better advantage. He was glad to find that Mr. Hodges had departed from the old-fashioned rules regarding the strength of the tubbing. Everybody would agree that if he had taken one of the formulæ quoted in his paper, he would not have had to wait very long before the whole thing came in. The question of the strength of the tubbing required unfettered consideration, from the point of view of the greater diameter of the shafts now than in the past. He thought that Mr. Hodges had not put too great a thickness of metal, considering [redacted]

(Mr. Barnes) was not much surprised at this, as even at modern collieries, workings were sometimes commenced too near the shaft, and destroyed its stability.

The idea of having the thicknesses of the tubbing cast on in relief figures for future reference was not usual, but it was an improvement. It was also unusual to coat tubbing and cribs with protective composition, but it should have the effect of preventing corrosion, although it might be doubted whether the coating did not hide flaws, sand-holes and honeycombing. The sending down of complete bolted-rings of tubbing appeared to have been a success; but, of course, this could not be done with tubbing that required wedging. It would be interesting to know how the horizontal and vertical sheathing was inserted. The time taken to complete the 140 feet length of tubbing, in less than two days, probably established a record.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN DOWELL'S ROOMS, EDINBURGH, OCTOBER 13TH, 1906.

DR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. JAMES AITKEN, 5, Allanton Terrace, Hamilton.
Mr. THOMAS CHAPMAN MURRAY, 14, Duke Street, Edinburgh.
Mr. HUGH SLOAN, Beechwood, New Cumnock.
Mr. EDMUND BESSELL WHALLEY, 4, Kirkbrae Road, Liberton, Edinburgh.

ASSOCIATE MEMBERS—

Mr. THOMAS BOYES, Larkhall.
Mr. THOMAS BROWN, 68, Mitchell Street, Glasgow.
Mr. JOHN GREENLIE, 45, Hope Street, Glasgow.

STUDENTS—

Mr. VIVIAN B. GRAY, 10, Oakfield Terrace, Glasgow.

[redacted]

the intake-air with which the porous ball was filled; this would increase the fire-damp indication; and in extreme cases, when the difference of humidity was very great, the moisture might produce indications, even in the entire absence of fire-damp. It was evident from the law of the diffusion of gases that the presence of carbon dioxide in the air that was being tested, might reduce or neutralize the indication of fire-damp. The indications of the instrument were also affected by the difference of temperature and pressure between the air contained in the porous ball and the air being tested. In a dusty mine, the porous ball would become clogged up in a comparatively short time, and this, of course, would retard diffusion. Apart from these disadvantages, the instrument was too cumbersome to carry, and required too much preliminary preparation before a test could be made.

Mr. HENRY C. HARRIS (Glasgow) wrote that Mr. C. Latham's criticism* of the McCutcheon indicator was unfair, comparing it, as he did, with the Ansell indicator. The two instruments certainly worked on the same principle, but the latest invention by Mr. McCutcheon had great advantages over Mr. Ansell's. About six years ago, at Armstrong College, Newcastle-upon-Tyne, Dr. F. C. Garrett gave a demonstration with the Ansell indicator, and from what he saw at that time, and from what he knew about the McCutcheon indicator, the following comparison might be drawn:—

	Ansell Indicator.	McCutcheon Indicator.
(1) Principle ...	Diffusion of gases.	Diffusion of gases.
(2) Portability ...	Not portable for use in mines.	Portable for use in mines.
(3) Liquid column ...	Fixed, with the following disadvantages:—(a) A rise of 2¼° Fahr. in temperature will ring the bell. (b) A rise of ⅓ inch of barometric pressure will ring the bell.	Not fixed. The column of azine is under the command of the user, and can be altered, at will, to suit the varying temperatures and pressures before making a test.
(4) Graduation ...	Not graduated to show the percentages of fire-damp present.	Graduated to show the presence of from 1 to 6 per cent. of fire-damp.

The McCutcheon instrument should prove of great value to managers and under-managers, as a delicate fire-damp detector, viz.:—(1) For detecting small percentages of fire-damp in main

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 243.

return air-ways; (2) for detecting small percentages of fire-damp in main intake air-ways, where shot-firing is being carried out, and where fine coal-dust exists; (3) for the periodical examination of mines, where naked lights are in use; and (4) for use in underground motor-houses.

Mr. T. Lindsay Galloway (Glasgow) asked whether Mr. Livingstone had found the instrument very cumbrous to work.

Mr. A. Livingstone (Bo'ness) replied that the detector had been improved since it was used at Kinneil colliery. He thought that this instrument was well adapted for use in motor-houses or any other place where there was any likelihood of gas lodging.

The President (Dr. R. T. Moore) said that the instrument had the disadvantage that a supply of fresh air was required in every test. It might be useful for testing main air-ways, but he did not think that it would be at all likely to replace the ordinary examination by the fireman.

The discussion was closed, and a hearty vote of thanks was awarded to the author for his interesting paper.

DISCUSSION OF MR. JAMES CALDWELL'S PAPER ON THE "ELECTRIC POWER-STATION, WINDING-GEAR AND PUMPING-PLANT OF THE TARBRAX [redacted]

for which the installation was designed did not embrace a peak-load of 400 horsepower. Under the conditions laid down, namely, an output of 640 tons in 8 hours from a depth of 420 feet, representing a full load of 25 cwts. per wind, the wind occupying 25 seconds, decking operations 30 seconds, making the period for a complete wind 55 seconds, it was arranged that the acceleration-period should be 10 seconds, during which the load was brought from rest to a maximum speed of 23 feet per second, at which it was maintained for the next 11 seconds; and 4 seconds were allowed in which to bring the load to rest. These conditions then, if adhered to, allow only of a peak-load considerably under that stated. The end of the tenth second must, therefore, be that instant of time at which the load reached the maximum, and this was estimated to be about 283 horsepower. Similarly the negative peak-load was found at the beginning of the twenty-second second to be 67 horsepower, the efficiency in this case being reversed, that is to say, the calculated peak-load was about 84 horsepower; but, with an efficiency of 80 per cent., the energy returned to the central supply was at the rate of ($84 \times 80 \div 100$ or) 67 horsepower.

The various functions, carried out at the average colliery, comprizing pumping, coal-cutting, hauling, winding, conveying, washing, screening, lighting, ventilating and air-compressing, necessitate widely scattered positions for their operations, which are effected by eight or ten different engines. The various means adopted to obtain high thermal efficiency in ordinary practice are all more or less applicable to these engines; and, with the exception of the pumping and compressing sets, most of these engines are worked, as a rule, non-condensing. The expense of providing and maintaining separate condensers for eight or more separate engines would be a questionable investment. Collieries might, therefore, be considered especially adapted for electrical power-transmission, and the success of such a winding apparatus as that at Tarbrax mine must go far to solve objections which have been urged against centralization of power and electrical distribution. The Ilgner winding apparatus had great possibilities, and he (Mr. Ness) was of opinion that the economies to be effected by its application to coal-winding would, sooner or later, tend to revolutionize the present methods. Safety was the chief, although not the only, consideration in

winding machinery, and any departure from existing practice would naturally be closely examined from this point of view. The ordinary steam winding-engine had many disadvantages, but it was so well understood, and there were so many trained drivers in the country, that comparatively little trouble was experienced in respect to safe working. In most collieries, safety-appliances were installed which automatically stopped the engine on emergency, or in the event of failure of the ordinary appliances. In this respect, the Ilgner apparatus appeared to be abundantly provided. The machine was under perfect control, and there were safe-guards which would meet any emergency, such as illness or momentary negligence on the part of the operator. Electric haulage and electric hoists, or lifts (which were comparable in this respect), had already long passed the experimental stage, and the methods of control in these installations were quite satisfactory. The experience at Tarbrax showed that the winder was under complete control, and that the details of the design were eminently satisfactory from the point of view of safety.

The winder was working at only about half of its rated output, and the economy at present obtained must be considered on this basis. There could be no doubt that, when working up to its rated output, the winder would show a still greater economy. A test was carried out on the winding-plant in July, 1906. The load per wind was about 12½ cwts. of shale. The test extended [redacted]

possibly be found that steam-winding would be more economical; but for small depths, such as at Tarbrax, there could be no doubt that such an installation would prove completely successful. In many collieries, where heavy lifts are raised from great depths, electrical winding, by the Ilgner principle, apart from the mechanical difficulties which were obvious, would become commercially impossible on account of the great costs involved; but, for 75 per cent. of the collieries in this country, the Ilgner system of mechanical storage would be commercially and mechanically successful. It should be remembered, however, that there were very many collieries where winding absorbed practically two-thirds of the whole power; but, with certain exceptions which would require careful consideration, there was no reason why, with such a storage and balancing system, mechanical and commercial success should not be achieved in centralizing the power and transmitting it by electrical means.

Mr. T. LINDSAY GALLOWAY asked what was the efficiency of the winding-engine.

Mr. NESS replied that the efficiency had been adversely affected by the fact that the load was only 50 per cent. of that for which the plant had been constructed; and under these circumstances the whole efficiency was about 47¼ per cent. He thought that, as nearly as possible, 115 feet had been traversed up the shaft when the peak-load was reached. On the day of the trial, about 16 per cent. of the total energy was returned to the system when the winding motor acted as an electric brake and became a dynamo. The cost of the production of an electrical unit might be taken at ½d., so that the cost would be rather under ½d. per ton of shale raised. He was informed that, before electric winding was installed, it took about ½ cwt. of coal to wind a ton of shale, and the cost might be roughly reckoned as about 2d. per ton.

Mr. J. B. SNEDDON asked whether the cost of pumping water had been separated from the cost of winding.

Mr. NESS said that he purposely confined himself to the fact that by test the figures showed a consumption of 0·866 unit per ton of shale raised, and he merely mentioned incidentally the information which had been supplied to him as to the former

cost of winding. His impression was that the cost of pumping was not included. In the case of the Tarbrax plant, it was probable that the cost would come under the figure given, as the costs at the central station would be charged against a number of different operations. He had not made an estimate of the charges for interest, depreciation, oil, stores or attendance; but ½d. would probably cover the cost of the unit delivered at the winding-house switchboard.

Mr. T. Lindsay Galloway said he understood that the circumstances at Tarbrax were peculiar, and that the winding-plant could not be compared with an ordinary winding-plant. He thought, therefore, that the figure of 47¼ per cent. given by Mr. Ness referred only to the current on the wind. To ascertain the actual cost accurately there must be a further comparison.

The further discussion was adjourned.

A DIAMOND HAND-BORING MACHINE.

By JOHN B. THOMSON.

This short paper is intended to bring before the notice of the members a handy machine for boring comparatively short holes and more especially for use in underground work.

Fig. 1.—Hand-boring Machine.

A description of the mechanism is scarcely required, as Figs. 1 and 2 shew the main features of the machine, and the principle is the same as that of the steam-driven boring machine having a steel-crown studded with diamonds, a core-tube, and hollow rods to allow water to be pumped down so as to keep the crown cool

and clear away the sediment. The power for revolving the crown, however, is applied by two men, one driving each of the handles. The men can maintain a speed of 100 revolutions per minute on the handles, and the crown-head is direct driven by gear-wheels at 100 revolutions per minute. While the crown is revolving, another man works a small hand-pump, *a*, forcing down water to clear away the fine sediment. The quantity of water required is about 3 gallons per minute.

[redacted]

is not sufficient to press down the crown, the lever is loaded with weights, and the ratchet is so placed as to assist the weight of the rods. These weights are diminished as the weight of the rods increases; and, when the rods become too heavy, the lever is brought over to the other side, and weights are added to counterbalance the weight of the rods.

The crown-head is fitted with diamonds in the usual way, and eight diamonds of 2½ to 3 carats each are required for a hole 2⅝ inches in diameter. The diamonds used for boring in the ordinary run of Coal-measure strata are known as "bort," and cost about £1 10s. per carat. For boring in very hard substances such as granite or very tough whin, those known as "carbons," are used, and cost about £6 5s. per carat. The crown is fitted with a spring for breaking off the core. Another very effective way of doing this is to break up a piece of brick to the size of peas, and pump it down with the water. The pieces of brick jam themselves in the crown, and when it is drawn away the core is broken off.

The core is 1⅞ inches in diameter, and when the coal is of a hard nature cores of this size can be got; but, when it is soft, the core is broken. However, the sample is usually better than any that can be got with a hand-saw.

The core-tube, about 12 feet long, is fitted at the top with a mud-box, which catches any of the heavier grit that the water may not be able to force to the top, and prevents it from falling back to the crown-head. The rods are made in 9 feet lengths and the head-room required underground is about 12 feet from the pavement to the top; and 6 feet of this height may be made in the form of a hole, about 3 feet square.

The machine is mounted on wheels, and, when at work, is clamped to the rails. When the rods are being drawn, it is run back about 3 feet out of the way. It weighs about 4½ cwts., and measures 6¾ feet in height, 5¾ feet in width, over the handles, and 4½ feet in length; and it is easily dismounted for putting underground.

Only four men are required to work the apparatus, two at the handles, one pumping water and a leader. They take turns at the handles for ½ hour at a time, so that each man has 15 minutes of rest in each hour. This number of men can put down a bore-hole to a depth such that it would be desirable to draw the rods by other means than a hand-crane.

A bore-hole has been put down, with this machine, to a depth of 725 feet. It was started on May 11th, 1906, and finished on August 1st, 1906. From May 18th to 23rd, inclusive, the borers were engaged at another shallow bore-hole that had to be put down at the time. In all, 557 shifts were spent in putting down this bore-hole, a depth of 725 feet. The diameter of this hole for 90 feet was $4\frac{3}{4}$ inches; thence down to 348 feet, it was $4\frac{1}{8}$ inches so as to allow tubes to be inserted; and, from 348 feet to the bottom, the hole was $3\frac{1}{4}$ inches in diameter.

As a contrast to this, the time spent at a chisel bore-hole put down to a depth of 626 feet in the same strata, bored from the surface, was from March 26th, 1901, to September 27th, 1901; 793 shifts were spent at it. The diameter of this hole was $2\frac{1}{2}$ inches.

Another bore-hole put down with the hand diamond drill was 264 feet deep. It was started on February 28th, 1906, and finished on March 16th, 1906; and 144 shifts were spent at it. The diameter of this hole was $2\frac{5}{8}$ inches.

The President (Dr. R. T. Moore) said that it had always been a wonder to him that the method described, seeing it had been so much used in the colonies, had but recently been employed in Scotland. It seemed to him to afford an excellent way of getting an accurate journal of the strata.

[redacted]

get working, as the ordinary lever for chisel-bores required; and a hole could be put down in at least one-third of the time that it could be done with the chisel. He had now made up his mind that a chisel would never be used again by him in putting down bore-holes, either underground or on the surface. The hand diamond-drill was capable of putting down bore-holes to a depth of at least 800 feet; and how much further it could go he was not prepared to say.

Mr. ANDREW KYLE (Galston) said that he had placed thirty chisel-bores in the shale-district before a start was made with the hand diamond-machine. They could bore with the hand diamond-machine as compared with the chisel-bore a hole in one-third of the time in that district; and for underground use, he maintained that there was absolutely no comparison between the two. When a depth of 250 feet was attained everything was against them with a chisel-bore; but with the hand-machine, even at a depth of 700 feet, they went on as steadily with four men as they did at the beginning. Four men were sufficient for boring to a depth of 600 or 700 feet, but with a chisel-bore seven or eight men were required. A hole had been put down to the depth of 810 feet at Dalmellington with a hand-machine; but if the hole was to be put down deeper than 500 feet, they preferred that a steam-machine should be used. An underground bore-hole, at Oakbank, was commenced on April 2nd, and finished on July 7th, 1906, the depth being 510 feet, passing through over 30 feet of hard whin and about 30 feet of limestone. These hard rocks, if bored by the chisel, would have taken over two months. This bore-hole was made in about one-third of the time that it would have taken to bore it by the old style of lever and chisel. An underground boring at Chamber colliery, Hollinwood, Manchester, was started on May 31st, and finished on June 20th, 1904, the total depth being 220 feet.

The further discussion was adjourned.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT UNIVERSITY COLLEGE, NOTTINGHAM, SEPTEMBER 8TH, 1906.

MR. W. G. PHILLIPS, PRESIDENT, IN THE CHAIR.

The SECRETARY announced the election of the following gentlemen :—

MEMBERS—

Mr. FRANCIS EDWIN ARMSTRONG, Assistant Manager, Newdigate Colliery, Bedworth.

Mr. CYRIL H. DODD, Mining Engineer, Pentre Hill, Mold, North Wales.

Mr. ARTHUR JAMES HAYNES, Colliery Manager, Kilburne Colliery, near Derby.

Mr. WALTER HUGH PHILLIPS, Under-manager, Ellistown Collieries, Coalville, Leicester.

Mr. WILLIAM WALKER, Colliery Manager, Gedling Colliery, Nottingham.

Mr. MATTHEW EYRE WILD, JUN., Colliery Surveyor, Holly Bank, Kimberley, Nottingham.

ASSOCIATE MEMBER—

Mr. JAMES HENRY PRAGNELL, 24, Swinburne Street, Derby.

ASSOCIATES—

Mr. ARTHUR EMERY BOOTH, Miner, 120, Derbyshire Lane, Hucknall Torkard,

[redacted]

ANNUAL REPORT OF THE COUNCIL, 1905-1906.

The following statistics show the change of membership and the financial condition of the Institution for the past three years:—

	Year 1903-1904.	Year 1904-1905.	Year 1905-1906.
Honorary Members ...	15	16	16
Life Members ...	6	6	6
Members ...	275	283	283
Associate Members ...	3	4	6
Associates ...	62	59	64
Students ...	37	39	42
Totals ...	398	407	417

	£ s. d.	£ s. d.	£ s. d.
Cash receipts ...	631 5 0	567 14 6	572 7 11
Cash payments ...	651 0 2	546 3 0	563 10 11
Bank-balance ...	179 13 11	201 5 5	211 2 5
Invested funds ...	640 0 0	640 0 0	640 0 0
Totals ...	£819 13 11	£841 5 5	£851 2 5

The following table shows the alteration in membership during the past twelve months, most of the resignations being caused by members ceasing to pay their subscriptions:—

	1904-1905	Less: Dead.	Less: Resigned.	Less: Transferred.	Add: Elected.	Add: Transferred.	1905-1906.
Honorary Members	16	—	—	—	—	—	16
Life Members ...	6	—	—	—	—	—	6
Subscribing Firm	1	—	—	—	—	—	1
Members ...	283	8	10	—	16	2	283
Associate Members	4	—	—	—	2	—	6
Associates ...	59	—	4	—	9	—	64
Students ...	39	—	—	2	5	—	42
Totals ...	408						418

There have been ten general meetings of the members during the past twelve months, two being those of The Institution of Mining Engineers, four of this Institution, three of the Midland Institute of Mining, Civil and Mechanical Engineers, and one a joint meeting of the two last-named. All have been well attended, and several interesting papers have been contributed by the members of the Institution.

The thanks of the members are due to owners of collieries and other works, who have kindly permitted a thorough inspection of the same on the occasion of various excursions, and have been good enough to entertain them most hospitably.

THE MIDLAND COUNTIES
Dr. THE TREASURER IN ACCOUNT

	£	s.	d.	£	s.	d.
289 Members, as per list, 1905-1906						
13 *less*, 6 Life Members, and 7 paid in advance						
276						
2 of whom paid at 15s.	1	10	0			
274 Members at £1 11s. 6d.	431	11	0			
				433	1	0
1 Member transferred, at £1 11s. 6d.				1	11	6
4 Associate Members, as per list, at £1 11s. 6d.				6	6	0
98 Associates and Students, as per list						
5 of whom paid in advance						
93 Associates and Students at £1				93	0	0
2 Students paid difference as Members and Entrance-fees ...				2	4	0
13 New Members and Entrance-fees				34	2	6
2 New Associate Members						
1 paid in advance						
1 New Associate Member at £2 12s. 6d.				2	12	6
14 New Associates and Students						
4 paid in advance						

[redacted]

INSTITUTION OF ENGINEERS.
WITH SUBSCRIPTIONS, 1905-1906. **Cr.**

	Paid. £ s. d.	Unpaid. £ s. d.	Struck off List. £ s. d.
224 Members at £1 11s. 6d.	352 16 0	......	......
32 Members unpaid	... ..	50 8 0	......
3 Members struck off	......	......	4 14 6
8 Members deceased	......	......	12 12 0
7 Members resigned	.....	......	11 0 6
2 Members at 15s.	1 10 0	......	......
276			
4 Associate Members at £1 11s. 6d. ...	6 6 0	......	......
63 Associates and Students at £1 ...	63 0 0	......	......
24 Associates and Students unpaid ...	......	24 0 0	......
3 Associates and Students struck off ...	......	......	3 0 0
1 Associate and Student resigned ...	......	......	1 0 0
2 Associates and Students transferred ...	2 0 0	......	......
93			
1 Member transferred, at £1 11s. 6d. ...	1 11 6	......	......
2 Students paid difference as Members, and Entrance-fees	2 4 0	......	......
13 New Members and Entrance-fees ...	34 2 6	......	......
10 New Associates and Students ...	10 0 0	......	......
1 New Associate Member	2 12 6	......	......
The Butterley Company	5 5 0	......	......
Subscriptions paid in advance	29 7 6	......	......
	510 15 0	74 8 0	32 7 0
Arrear-subscriptions	38 9 0	29 6 6	16 12 0
	549 4 0	103 14 6	48 19 0
			103 14 6
			549 4 0

Audited and found correct,

JOHNSON PEARSON,

AUDITOR.

August 21st, 1906.

£701 17 6

[redacted] Engineers: Abstract of Accounts for the Year ending July 31st, 1906.

	d.	£	s.	d.
[redacted]		201	5	5
	0			
	6			
	0			
	—	357	10	6
	...	6	6	0
	...	63	0	0
	...	34	2	6
	...	2	12	6
	...	1	10	0
	...	10	0	0
	...	5	5	0
	...	1	1	0
	...	29	7	6
	...	1	10	0
	...	0	16	0
	...	15	4	0
	...	38	9	0
	...	2	5	2
	...	4	8	9
		£774	13	4

Payments.

				£	s.	d.
Postages, parcels, telegrams, etc. ...				16	15	7
Stationery and printing ...				40	1	8
Books ...				2	2	5
Exchanges and excerpts ...				4	4	11
Expenses of meetings ...				10	4	7
Reporting ...				5	4	6
Railway fares and expenses ...				16	2	0
Fire insurance ...				0	3	6
Auditors ...				3	3	0
Rent of room for library ...				2	10	0
Secretary's salary ...				100	0	0
The Institution of Mining Engineers:—						
Call 1905-1906:—Vols xxx. and xxxi.	£325	17	0			
,, 1904-1905:—Vols. xxviii. and xxix.	14	5	0			
Arrears ...	22	0	0			
				362	2	0
Bank commission ...				0	16	9
Balance in bank:—						
Current account ...	6	13	8			
Deposit account ...	200	0	0			
Interest on deposit account ...	4	8	9			
				211	2	5
				£774	13	4

Audited and found correct,

JOHNSON PEARSON, Auditor.

August 21st, 1906.

The Council have taken an active part in pressing for the issue of the *Transactions* to members within a reasonable period, and at the London meeting of the Council held on June 14th, 1906, the following resolution, which it is hoped will have the desired effect, was carried:—

In order to expedite the issue of the *Transactions*, it is resolved that all matter for publication in the *Transactions* shall be supplied to the Secretary, properly edited by the local Institutes, within one month of the meeting, and shall appear in the *Transactions* and be issued to the members not later than two months from the date of the meeting of which it is the record. The issue of any part of the *Transactions* shall not be delayed on account of any local Institute not conforming to this rule.

The Council much regret to record the death of six members during the past year, namely:—Messrs. George Lewis, William Holding, William Nowell, James Pearson, Hargrave Walters and H. Wilkinson. These were all active members of the Institution, and, in particular, Mr. George Lewis served the office of President of this Institution and of The Institution of Mining Engineers, and rendered invaluable services during his membership of 34 years' duration.

The President (Mr. W. G. Phillips) moved the adoption of the report and statement of accounts.

Mr. G. H. Ashwin (Sheffield) seconded the resolution, which was unanimously agreed to.

ELECTION OF OFFICERS, 1906-1907.

The report of the Scrutineers was presented as follows:—

President:
Mr. W. G. Phillips.

Vice-Presidents:

Mr. G. H. Ashwin.	Mr. W. Hay.	Mr. J. H. W. Laverick.
Mr. G. C. Fowler.	Mr. W. H. Hepplewhite.	Mr. J. Piggford.

Councillors:

Mr. P. Beaumont.	Mr. C. R. Hewitt.	Mr. J. Mein.
Mr. G. J. Binns.	Mr. J. P. Houfton.	Mr. E. D. Spencer.
Mr. J. W. Fryar.	Mr. B. McLaren.	Mr. G. Spencer.
Mr. R. H. F. Hepplewhite.	Mr. B. Madew.	Mr. J. T. Todd.

Mr. William Maurice's paper on "A Rateau Exhaust-steam-driven Three-phase Haulage Plant" was read as follows:—

A RATEAU EXHAUST-STEAM-DRIVEN THREE-PHASE HAULAGE PLANT.

By WM. MAURICE.

Introduction.—The purpose of this paper is to record the application (for the first time in British mining practice) of a new force, as it were, amongst modern methods of power-production; methods the constant object of which is to use the greatest possible quantity of the heat stored in coal and to transform the maximum amount of this heat into mechanical work.

Our lamentable incapacity to wrest any substantial proportion of nature's forces from their stores is impressed upon us forcibly when we contemplate the fact that so far we can only utilize as useful mechanical energy in our machinery from 2 to 10 per cent. of the heat which is theoretically available.

The chief sources of loss of power to which engineers are directing their attention are the following:—Coal-dust; gases which by the incomplete combustion of coal pass into the chimneys in addition to the immense volume of carbon monoxide which escapes in the same way; radiation from boilers,

[redacted]

In collieries, the coal got at the pit's mouth for power-purposes is in itself of so little value as not greatly to affect the cost of production. A big coal-consumption necessitates, however, so much additional work, which has to be performed by expensive manual processes, that in this way the cost of production is seriously raised. The consumption of more coal involves the use of more boilers, and this means greater capital outlay, greater amortization, more extensive personnel for stoking, cleaning and repairs, perhaps also water to pay for (if not directly, then through water-softeners), increased insurance-rates, and greater probability of breakdown and danger.

By patient and continuous research a good deal has been done to remedy, at any rate partly, the inefficiencies to which reference has been made. By the use of high-pressure boilers, steam-jacketed high-pressure compound and triple-expansion engines, condensation of exhaust-steam, heating of feed-water, automatic stoking, and so forth, and more recently by developments in the use of electric winding-engines, considerably increased efficiency has been gained in mining power-plant.

There remains, however, the energy lost in the exhaust-steam, and this is all the more serious because non-condensing engines are the most suitable for winding. Where winding-engines are used for raising both men and minerals, there can be no question that it is more satisfactory to have the control of the engine in the hands of the winder, rather than to have it dependent on the uncertainties of a condensing plant. This statement is borne out in practical experience by the fact that winding-enginemen who drive condensing winders usually disconnect the condenser, when raising or lowering men. Winding-engines again are compounded, as another means of economizing steam, but there is the difficulty of having to set the crank of the high-pressure cylinder so as never to stop on the dead centre at the end of a wind. This can be only partly remedied, because winding-ropes cannot be always adjusted with sufficient nicety, and difficulties are liable to arise when they require to be changed, or when it is necessary to wind from more than one level. To provide the engineman with an extra lever for the purpose of admitting high-pressure steam into the low-pressure cylinder amounts to saving steam on one side and spending it on the other, besides complicating the duties of the winder.

Consequently it is considered that the most successful winding-engines are those of the high-pressure non-condensing horizontal twin type, notwithstanding the fact that the steam exhausted from them contains an amount of energy equal to from 30 to 40 per cent. of the useful work done.

The exhaust-steam of a continuously-running engine was first utilized by Mr. C. A. Parsons, who coupled a turbo-alternator of his design with the exhaust-steam from the low-pressure cylinder of a compound engine. This combination might be regarded as a triple-expansion engine: the turbine forming the low-pressure cylinder.

In the case of winding-engines (and the same may be said of reversible rolling-mill engines) the intermittent nature of the exhaust-steam renders impossible the direct coupling of a low-pressure turbine, because such a combination would possess inconvenient variations of speed.

It is to Prof. A. Rateau, professor at the École Supérieure des Mines at Paris, that credit is due for having successfully overcome this difficulty. The problem is solved by intersecting between the reversible engine and the low-pressure engine a medium, the purpose of which is to take up the intermittent exhaust-steam from the primary engine, to accumulate this, to keep it under practically constant pressure, and to supply it to the secondary engine just as it could only otherwise be done by direct supply from the boilers.

the secondary engine, then the purpose of the invention is achieved, and the secondary engine can run under a constant speed driven by this artificial supply of steam.

Thus, it will be seen that the secondary engine, that is, the turbine, is supplied during part of its run directly with the exhaust-steam from the primary engine, namely the winding-engine. During this period, the accumulator or reservoir is nothing more than a common link between the source of the steam and the point of utilization. During another period, the turbine is fed by fresh steam raised (with the help of the heat stored in the metal contained in the reservoir) from the

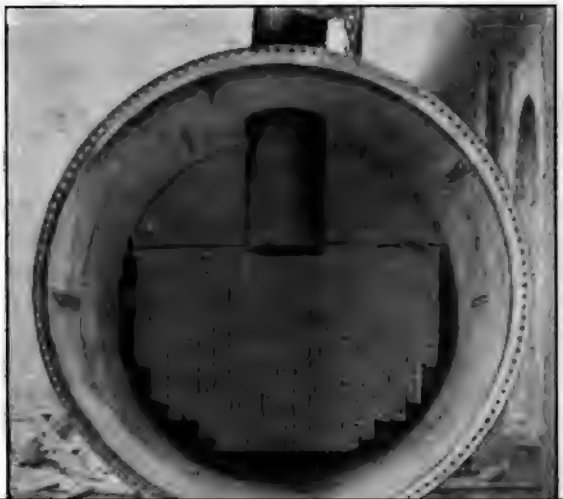
FIG. 11.—VIEW OF PLANT.

boiling water, which has been brought to boiling point by the passing and remaining of the exhaust-steam during the exhausting period.

In the Hucknall installation, which has been erected to the designs of Mr. P. J. Mitchell, the course of the steam may be traced by reference to the illustrations. From a winding-engine making 60 draws per hour, the exhaust-steam goes through the pipe-connection, B (Fig. 11), to the accumulator, C. The accumulator contains 50 tons of scrap-iron pit-rails, assembled horizontally and in parallel layers. Fig. 12 is an end view of the interior of the accumulator.

From this accumulator the steam passes through the pipe, E (Fig. 11), the main stop-valve, F (Fig. 13), the turbine-valve, G, and the throttle-valve, H, into the admission-side of the low-pressure turbine, I. Thence it passes through eight sets of discs, the exhaust-pipe, J, the injector-condenser, K, and the direct-acting pump (Fig. 14), to the hot well.

But, as the turbine cannot take all the exhaust-steam yielded by the winding-engine, the accumulator is supplied with an automatic relief-valve, N (Fig. 11), which is adjusted to open at an absolute pressure of 16 pounds per square inch. This



[redacted]

event of the winding-engine stopping longer than usual, a direct connection with the main boiler-gallery is made through a reducing valve, O (Fig. 13), which reduces the boiler-pressure of 55 pounds per square inch to 16 pounds of absolute pressure. The details of these connections will be found by reference to Figs. 1, 2, 3 and 4 (Plate VIII.). This reducing-valve is worked automatically by levers as shown, and is set to admit reduced live-steam from the boilers into the turbine, whenever the winding-engine remains idle for a longer period than 90 seconds.

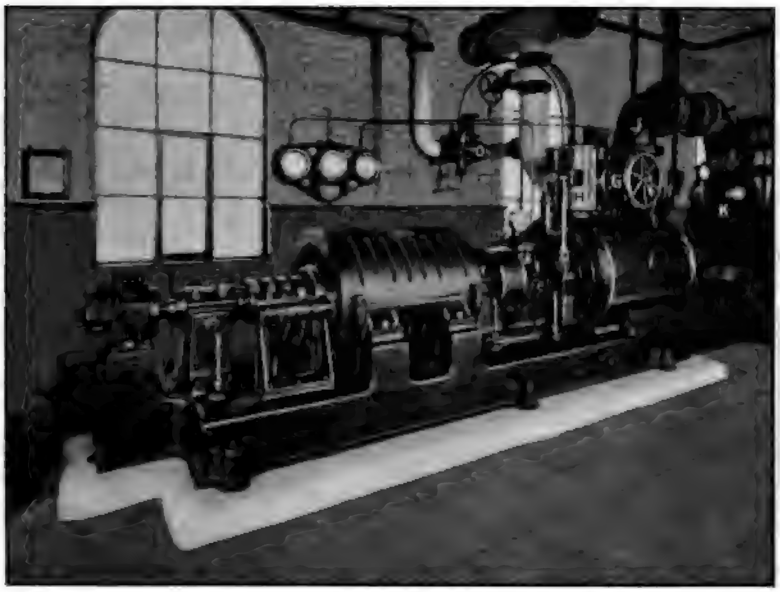
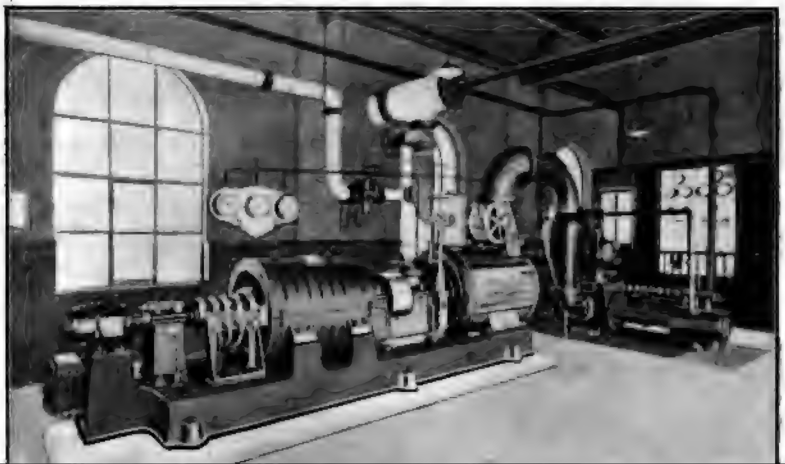


FIG. 13.—RATEAU TURBINE.

The application of this automatic reducing-valve brings out an interesting and important point bearing on the overall efficiency of exhaust-steam turbines.

It will have no doubt been frequently observed that, in order to maintain the required number of draws per hour from a winding-engine, the boiler-pressure must be kept as near as possible to the blowing-off point. Consequently, when winding is delayed, steam blows off at the safety-valves, and energy is wasted beyond any possibility of recovery. But by the aid of the automatic reducing valve, an appreciable portion of this otherwise waste-steam will go through the turbine, just at the

moment when the latter cannot obtain exhaust-steam owing to the cessation of winding. In this way, a high general efficiency is obtained, even when working with old low-pressure boilers and winding-engines, without automatic expansion-gear. In the case of the Hucknall turbine, it has been noted that there is no appreciable change in its speed when fed with steam from any of the three sources of supply, namely, live-steam, exhaust-steam and regenerated steam in the accumulator, the automatic change, from one supply to either of the others, being so gradual that there is no perceptible difference of pressure on the admission-side of the turbine. If there is any change in the com-



[redacted]

The greater part of the power developed by the alternator is used for haulage in the mine where the plant is installed. Since, under the local conditions, no coal-winding can go on without haulage and no haulage can be done without winding, the plant works under circumstances favourable to economy.

Whilst power is wanted for haulage the turbine can be driven by exhaust-steam; but if it had to run, say, for the purpose of operating electric pumps during the night-shift, or to do other work during intervals between coal-turning shifts, it would then be necessary to run on reduced live-steam. The efficiency of the plant would thus be reduced by nearly 50 per cent., as compared with that of a good type of compound engine.

It would perhaps have added to the interest of this paper, if tests could have been carried out showing the consumption of exhaust-steam per horsepower-hour.

There is undoubtedly a large margin of surplus exhaust-steam escaping into the atmosphere, and it is probable that the full output of the generator could be obtained with little more steam than is supplied by one cylinder of the winding-engine.

Haulage.—The Rateau installation was put down primarily to supply power for underground haulage. The latter presents no points of novelty. It is an old plant, and works, of necessity, under conditions the reverse of ideal. The mine has been producing coal for a period bordering upon half a century, many districts are exhausted, and a large proportion of the total output is now dependent upon three sets of ropes, all of which are geared to one source of power. The original scheme consisted of three vertical multitubular boilers, supplying steam at a pressure of 60 pounds per square inch to an engine with two coupled horizontal cylinders, each capable of developing, approximately, 40 horsepower. This engine drove the above-mentioned ropes through suitable gearing, each rope-drum being provided with a claw-clutch of the ordinary type.

An examination of the figures obtained by calculation, and those since measured by electrical instruments, may prove interesting. The power required in the motor-house could not be determined by steam-engine tests, the ropes having been extended so many times that the original installation had become considerably underpowered.

In the mine there are two districts (Fig. 6, Plate VIII.), each worked by an endless rope, and a third rope which is used to divide the output of one of these districts into two parts, taking half along a bye-road to feed the upper decks of the winding-cage.

No. 1 District.—This district is estimated to deliver 1,000 tons per shift of $7\frac{1}{2}$ hours, but, to allow for delays, the actual running time is taken at 6 hours. The speed of the haulage is 4,000 yards per hour, the weight of the empty trams is 6 cwts.; and the net weight of the loaded trams is 12 cwts.

To deliver 20,000 cwts. per 6 hours requires ($20,000 \div 12$ or) 1,666 tubs, that is, ($1,666 \div 6$ or) 278 tubs per hour. A speed of 4,000 yards per hour gives ($4,000 \div 278$ or) 14·5 yards as the distance apart of the tubs; and on a road, 3,760 yards long, there will, therefore, be ($3,760 \div 14{\cdot}5$ or) 260 loaded tubs on the rope.

The net load on the rope is, therefore (260×12 or) 3,120 cwts.; and this gives, allowing for a gradient of 1 in 100 in favour of the load, a pull of 31·2 cwts.: taking the friction-coefficient of the trams as $\frac{1}{35}$, the power required to pull the trams is, therefore, ($3,120 \div 35 - 31{\cdot}2$ or) 58 cwts. The weight of rope, at 4 pounds per yard, is ($3,760 \times 2 \times 4$ or) 30,080 pounds: assuming the friction-coefficient of the rope at $\frac{1}{20}$, the pull will be ($30,080 \div 20$ or) 1,504 pounds. The total pull is, therefore, ($6,496 + 1,504$ or) 8,000 pounds; and the horsepower will be ($8,000 \times 200 \div 33,000$ or) 48·5.

No. 2 District.—In a similar way, the horsepower required for No. 2 district, which, though considerably shorter, works [redacted]

(1,800 millimetres) in diameter. The shaft, C, is 4·92 inches (125 millimetres) in diameter. The pinion, D, is 24·61 inches (625 millimetres) in diameter and 5·91 inches (150 millimetres) wide. The wheel, E, is 70·87 inches (1,800 millimetres) in diameter and 5·91 inches (150 millimetres) wide. The shaft, F, is 5·91 inches (150 millimetres) in diameter. The pinion, G, is 19·68 inches (500 millimetres) in diameter and 5·91 inches (150 millimetres) wide. The pulley, H, is 98·43 inches (2,500 millimetres) in diameter and 5·91 inches (150 millimetres) wide. The shaft, I, is 7·87 inches (200 millimetres) in diameter. The No. 3 bye-road rope-driving pulley, J, is 39·37 inches (1,000 millimetres) in diameter. The rope-driving pulleys, K and M, for Nos. 1 and 2 districts are each 55·12 inches (1,400 millimetres) in diameter and can be put into and out of gear by the clutches, L and N.

The diagram (Fig. 9, Plate IX.) gives an idea of the conditions under which the motor works. During the first 2 minutes, only the No. 2 and the pit-bottom ropes are running, the current taken being about 50 amperes. Then both ropes are stopped, and the pit-bottom rope is switched on alone. After 3 minutes, the north rope is started and runs for ½ minute. From the fifth to the thirteenth minute, the bottom rope runs, then No. 2 rope is started and, at 14½ minutes, No. 1 rope is thrown into gear. The current rises momentarily to 144 amperes, falls to 80 amperes as the ropes acquire speed, and then rises, in 1½ minutes, to 90 amperes. This indicates the occurrence of something abnormal on the road, perhaps a tram derailed, and the driver consequently switches off. At 17 minutes, he starts the No. 1 and pit-bottom rope for about 1¾ minutes, then stops to throw into gear the No. 2 rope. The current rises to 135 amperes, drops to 80 amperes, and shows sharp variations of current between 70 and 90 amperes during the ensuing 3 minutes. At 22 minutes, the motor is stopped to take No. 2 rope out of gear and starts again with the other two ropes. At 35 minutes, the rise in the current-line makes it evident that there is something wrong on the road. The current is switched off 2 minutes later, and the No. 1 rope is not started again until 43½ minutes. This chart was selected to show bad conditions, partly to indicate what a well-made three-phase motor will do, and partly to show the disadvantages of working without friction-clutches.

Fig. 10 (Plate IX.) shows the average amperage for each rope, when running separately, by the lines A, B and C. The amperage, when all three ropes are running together, is marked by the line D. It will be observed that this line is not equal to the sum of the currents taken by the separate ropes, since the latter may assist or retard one another, at certain points on the journey. The heavy dotted line, E, on the same chart, shows the average current taken by the motor over a whole day, and is not calculated from the line D.

It may be interesting, from the point of view of companies contemplating the use of current from external sources of supply, to state that the power-plant consumes 203 Board of Trade units, and the underground lighting 27 units, as recorded daily on a wattmeter.

Allowing 10 per cent. for depreciation of plant, and 5s. per day for labour, the cost per unit is 1·3d. when working only 250 days per annum. If the turbine ran 250 days per annum on the full load the cost per unit would be reduced to 0·55d. without allowing for the saving that would result from the consequent stoppage of another boiler. If it were possible to have a permanent night-load all the year round, the cost instead of falling again would rise slightly, since the plant would run two-thirds of its time on reduced live-steam, and would require to have charged to it a proportion of the boiler-expenses.

containing perforated oval tubes. The water covered the perforations, and was violently circulated by the steam issuing from them. As water had nine times greater heat-storage capacity than metal, the dimensions and cost of the apparatus were consequently greatly reduced. In reference to the pressure in the accumulators, as a rule the average pressure was about ½ pound per square inch above the atmosphere. It was slightly greater at Hucknall Torkard, for two reasons: (*a*) the quantity of rails available was hardly sufficient to take up enough heat at atmospheric pressure; and (*b*) the quantity of steam used from the winding-engine was so large that the relief-valve was hardly large enough, especially as the plant was not working at full load. The cost per unit appeared somewhat high, but it should be borne in mind that the average load on the motor was only about 60 out of a possible 150 amperes, and that the load varied from 160 to 20 amperes about 50 times per hour. The pit only worked 8 hours per day, and this also tended to increase the cost per unit. It had been proved, in steel-works with a variable load for 24 hours, that the cost including interest, depreciation, oils, stores, and wages varied from 0·25d. to 0·30d. per unit. Including plants installed on the Continent, there were altogether thirty-six Rateau plants, the greater number in Germany and one plant in America. The Hucknall Torkard plant had a capacity of 150 amperes at 500 volts, and was driven by a Rateau low-pressure turbine working from atmospheric pressure to a vacuum of 26 inches.

Mr. CHARLES H. MERZ (Newcastle-upon-Tyne) wrote that the installation of a Rateau turbine, receiver and dynamo to utilize the exhaust-steam from a colliery winding-engine was interesting, and the experiment was of material value as directing attention to economies in working and to the importance of raising coal to bank at minimum power-costs. From data at his disposal, it would appear that from 4 to 8 per cent of the total coal-output of the average mine was used for the purpose of satisfying the power-requirements of the pit-and-surface plant, so that any economy in these power-requirements was well worthy of consideration. An efficient power-company ought, however, to be able to offer electricity to mines on terms which would compare favourably with the results of the experiment as stated by Mr. Maurice at the end of his paper; and

one would therefore anticipate that the utilization of the exhaust-steam of winding-engines on the system described was hardly likely to be followed extensively, not, at any rate, within the area of a power-company.

Prof. A. RATEAU (Paris) wrote that a few supplementary remarks might prove useful, in order to show how it would be possible, when occasion arose, to surmount the difficulties inherent in the Hucknall-Torkard installation. It is certain that a heat-accumulator, utilizing a mass of metal, tends to become too bulky and especially too costly, when it is a matter of regulating the escape of steam from powerful intermittent engines. He had consequently been led to devise an apparatus wherein the heat-accumulator is constituted by a mass of water, whereof the calorific capacity is greatly superior to that of the metal utilized in the Hucknall-Torkard installation. There remained one considerable difficulty to be overcome, namely, the poor conductivity of water. In the Rateau water-accumulator, the steam penetrates the liquid in the most intimate fashion, being dispersed therein in tiny bubbles by means of tubes riddled with perforations of small diameter. By means of a special arrangement of these tubes, a very active circulation is set up within the liquid mass, thanks to which the contact-surface between the steam and the water of the heat-accumulator is enormously extended, and so the whole of the water plays an active part in the regeneration of the steam. One of these appliances has been set up in the works

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expanded before it is taken up by the turbine. This case, as Mr. W. Maurice had pointed out, arises only when the winding-engine or the rolling-mill have rest-intervals during which the turbo-generator must, nevertheless, develop current. If these intervals are not of too long duration, there is evidently nothing for it but to accept the economically unsatisfactory use of expanded steam by the turbine. Should these intervals, however, be of considerable duration, it would be advisable to make use of turbines of the mixed-admittance type; these turbines have two points of entry for the steam. In the case of exhaust-steam, it enters through the low-pressure part of the turbine; but when it is desired to utilize high-pressure steam, that steam enters through the first blades (or spirals) of the turbine, and having passed over these, does its work in the low-pressure portion. These separate admittances of steam are automatically regulated by a specially-devised appliance. The utilization of the steam is, then, in all cases satisfactory from the economic point of view, and is comparable with, if not superior to, the results obtained from the best installations of electro-generators combined with piston-engines.

Among arrangements of the kind just described, that which has been set up at the Reunion mines in Spain, deserves, perhaps, special notice. There the question was how to utilize the steam from a winding-engine by means of a heat-accumulator and a turbine working at the pressure of one absolute atmosphere. The winding-engine is at work for about 10 hours a day, and the turbine, having to provide power during every hour of the twenty-four, is provided with three inlets for steam. This allows of its utilizing, under the most favourable conditions attainable, steam derived from the boilers at the respective pressures of 70 pounds and 135 pounds per square inch. Thus the turbine is supplied automatically with steam from three distinct sources: exhaust-steam, steam at 70 pounds, and steam at 135 pounds. (Steam at 70 pounds or steam at 135 pounds is used, according as one or other of the boilers is available.)

At the Béthune mines, in France, a centrifugal turbo-compressor, Rateau type, is also driven by low-pressure turbines, utilizing the exhaust-steam from a winding-engine. These turbines, two in number, are placed on two parallel shafts to which the air-compressors are coupled direct. One of the turbines is provided with high-pressure gear whence exhaust

takes place into the second low-pressure turbine, which drives the second shaft of the air-compressor. The exhaust-steam from the high-pressure engine, being diverted into the second low-pressure turbine, this allows of the maintenance of practically equal power on the two shafts of the turbo-compressor whilst working with live steam. In regard to this point, it is of interest to note that the Rateau turbo-compressor provides air at a pressure of 85 pounds per square inch.

From these supplementary remarks, it will be seen that it is possible so to utilize exhaust-steam that, whenever the main source of the low-pressure steam gives out, excellent results may yet be obtained from a given group of electro-generators.

It is clear that each installation must be studied for itself, in order to utilize in the best manner possible the available material. The suggested device is very adaptable, and can be modified to meet various contingencies. It does not consist in simply coupling up a low-pressure turbine to a compound piston-engine, for the last cylinder of which the turbine would act as a substitute, but it assures the complete independence of both. He (Mr. Rateau) might venture to assert that his system had now established itself thoroughly in the realm of industrial practice. The number of installations at work or under construction exceeds 30, representing the production of no less than 24,000 additional effective horsepower. In Great Britain, seven installations supply about 7,000 horsepower.

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Mr. W. PRICE ABELL (Derby) said that Mr. Maurice pointed out that winding required a varying power, and argued that a simple engine was the best for the purpose, and that the Rateau arrangement, in conjunction with an accumulator (and to that he attached the greatest importance), was a practical and feasible means of equalizing and economizing the volume of steam required for such a varying consumption as that possessed by an ordinary winding-engine; and the Rateau system afforded the beneficial reservoir or equalizer. However, the varying conditions of a winding-engine did not apply in the case of an ordinary engine developing a constant power, and he (Mr. Abell) failed to see that the Rateau system would give a greater economy than any of the efficient compound condensing engines of the present day. He thought that Mr. Maurice did wisely in stating, at the outset, the varying conditions which prevailed, and in leaving the members to draw their own conclusions from the work which he had achieved in actual practice.

Mr. R. LAVERICK (Wollaton) said that in the plant described by Mr. Maurice, the exhaust-steam was derived from one source of supply (the winding-engines); and he (Mr. Laverick) suggested instead of having occasionally to use live steam in the secondary engine that the exhaust steam from the fan-engine, and the belt-engine, should be utilized in a series of accumulators.

Mr. J. MEIN (South Normanton) asked whether the actual working of the plant had given entire satisfaction, how much per ton had actually been saved by the introduction of the new arrangement, and whether the large capital-expenditure had been justified by the saving of fuel that had been accomplished.

Mr. M. W. WATERHOUSE (Exhall) asked whether the Rateau turbine could be run at a speed low enough to drive an ordinary direct-current installation. It was stated that the automatic reducing-valve was set, so as to come into operation and to admit live steam from the boilers into the turbine, whenever the winding-engine was standing for longer than 1½ minutes. He did not understand how that was accomplished, and he should be glad of some further explanation.

Mr. W. Hay (Shirebrook) asked what was the back-pressure at the winding-engine?

Mr. J. W. Fryar (Eastwood) said that Mr. Maurice had stated that where condensing winding-engines were used the condenser was generally disconnected when men were being raised or lowered; but for the last forty or fifty years most of the coal in the North of England had been drawn by condensing winding-engines, and he had never heard of the condenser being disconnected when men had to ride in the cage. Mr. Maurice further stated that the cranks of compound winding-engines should be set at opposite centres; but he (Mr. Fryar) thought that there was no difficulty in setting them at right angles, and, further, that there was no difficulty in working compound winding-engines, either condensing or non-condensing. He felt so sure as to the efficiency of the Rateau turbine that they were erecting at the present time, at Bentley colliery, near Doncaster, two Rateau exhaust-steam turbines, which would utilize the whole of the exhaust-steam from the compound winding-engines, the fan-engine, and (during the sinking) from the high-speed non-condensing generator-engine. All of the exhaust-steam would be passed to the accumulator, and thence through the Rateau turbine to the condenser, in preference to passing the steam from the engines direct to the condenser. He believed that exhaust-steam used in that way would show considerable economy, even when compared with the use of condensing engines in the best electrical stations.

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tinent had also been running for considerable periods, so that their reliability was beyond question.

With regard to the points raised by Mr. Mein, the installation of the Hucknall plant was not at all in the nature of an experiment; and it was actually the cheapest available means of obtaining the power required, although the capital cost per horsepower would seem expensive owing to the small size of the machine. Before adopting the Rateau system, he (Mr. Maurice) had examined in detail the capital cost and probable running expenses of every other means of obtaining the necessary power, including the installation of a complete producer-gas plant. Then he saw the machine at the Bruay collieries, and afterwards saw others under construction. Mr. Mein had commented on the absence of detail with regard to the actual running of the plant, but there was really nothing to say. The turbine had given practically no trouble, nor had anything else occurred that was in any way novel. A little difficulty had been experienced in balancing the rotor, and there had been a few electrical troubles, but they were such as might occur with any kind of electrical generator, and had nothing to do with the installation considered as an exhaust-steam power-plant. The plant was now running efficiently, and he believed that all the little trials incidental to the starting of a finely built high-speed machine had been successfully overcome. The boilers, previously doing the work of this installation, were worn out, no other source of steam-supply was available, and eventually the haulage-gear was driven electrically, and an exhaust-steam turbine was provided to generate the power. There could be no question that the new installation was much cheaper to run than the old one; and, irrespective of interest and depreciation, the cost per ton for power was 0·06d. It was impossible for any other scheme to have worked out so low. The old installation cost rather more than this amount, solely on material for repairs.

It would undoubtedly be advantageous to utilize the exhaust-steam from all sources, if the power were wanted; but he had not troubled to collect other exhaust-steam, because that from the winding-engine alone was more than he needed.

The turbine ran at a speed of 3,000 revolutions per minute. There was no inherent difficulty about applying the system to direct-current generators, and, in fact, the Glasgow instal-

lation was so applied, as also was that at Bruay collieries. The automatic reducing-valve was of the usual type, and not specially designed for use with exhaust-steam turbines. The cost per unit was given at the end of the paper. There was a little back-pressure on the cylinder of the winding-engine, but not sufficient to affect the speed of winding or to interfere with the work of the engineman.

He (Mr. Maurice) agreed in general with the remarks of Mr. Fryar, and recognized that this regenerative principle should not be considered so much a rival as an auxiliary to an ordinary condensing installation.

The PRESIDENT (Mr. W. G. Phillips), in proposing a hearty vote of thanks to Mr. Maurice for his paper, suggested that they should have an opportunity for a further discussion on some future occasion.

The resolution was cordially adopted, and the further discussion was adjourned.

DISCUSSION OF MR. A. HALL'S PAPER ON "THE STANLEY DOUBLE-HEADING MACHINE."*

Mr. A. HALL, supplementing his paper, said that in the costs of working nothing was included for the actual costs of the air-compressor, the engine driving it, and the heading-machines; and no allowance was made for the value of the coal

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in diameter and 9 inches stroke, a pipe 4 inches in diameter should be used, if the air was to be brought from a distance of 3,000 feet. It could easily be shown that under such conditions the loss due to friction, quite apart from the loss due to leakage, would absorb a considerable quantity of power, and add still further waste to the present wasteful system of compressing air on the surface for use with these machines. To prove this point, he assumed that the heading-machine would have a cut-off in the cylinders of 0·90 stroke, and a working pressure of 30 pounds per square inch.* Under these circumstances, the equivalent free air required would be approximately 800 cubic feet per minute. The problem then was to determine the initial pressure required to transmit 800 cubic feet of free air per minute through a pipe, 4 inches in diameter and 3,000 feet long, so that it might have a terminal pressure of 30 pounds per square inch. By D'Arcy's well-known formula, he found that the initial pressure would be approximately 45 pounds per square inch. From this it would be seen that, to obtain the requisite quantity of air at the heading-machine at a pressure of 30 pounds, the compressor at the other end of the length of pipes must deliver the air into the pipes at a pressure of 45 pounds per square inch. Assuming ordinary single-stage compression in each case, the ratio of the power required to compress this air at a pressure of 30 pounds compared with that required at a pressure of 45 pounds would be as 19½ to 26, these being the relative mean effective pressures in the cylinder of an ordinary air-compressor under these conditions. This ratio was equivalent to a reduction of 30 per cent. in the power required under these two conditions. In other words, an electrically-driven compressor placed in-bye to compress the air at the pressure actually required, only needed to be 70 per cent. as powerful as if a standard compressor were used on the surface and the air transmitted through the lines of pipes in question. He (Mr. Abell) did not disagree with Mr. Hall as to the sizes of pipes that he had selected, because he realized that if colliery-managers put in still larger pipes so as to reduce the drop, it simply increased the capital cost of the pipes. He desired, however, to use this opportunity of pointing out, from figures given by practical men in connection with this work,

* *Trans. Inst. M. E.*, 1905, vol. xxx., pages 604 and 605.

such as Mr. Hall was, what a great economy could be obtained by electrical transmission, and compression underground close to the working-face. He would like to remark that when the air-compressor is installed in-bye, close to its work, the initial pressure, and, therefore, the power of the motor, could be largely reduced, and also advantage could be taken of the closeness of the air-compressor to the heading-machine to omit water-jackets from the compressor, and to compress the air hot and deliver it in that state to the heading-machine. The valve-setting on the heading-machine could be altered then so as to give a much earlier cut-off, thus enabling a much smaller air-compressor and motor to be used, and the cost of heading by means of these machines and in-bye electrically-driven air-compressors would be further reduced.

Mr. H. R. Hewitt (H.M. Inspector of Mines, Derby) wrote that he had watched the development of this heading-machine for many years and the single machine had done useful and rapid work in Warwickshire; but, in Derbyshire, where the roads were wider and higher, he had seen the machine at work driving opening headings, with sets of men further back pulling off the sides and ripping the roof, where the work was extremely hard owing to the strong nature of the coal. In coal of a friable nature it was found difficult to keep the road of a reasonable width where the double-header was used, and in the re-opening of the Charity colliery, it was found that the sides of the road- [redacted]

sure of 50 pounds, 104 cubic feet per minute. As Warwickshire mines are not much troubled by fire-damp, this scanty air-supply is sufficient for the head-end, but in a long heading the air, away from the machine, is somewhat stagnant and foggy. He thought that considerable difficulty would be experienced in working a double-header to the rise, owing to its weight of 6 tons, and perhaps the author would describe how this enormous mass was kept up to the cutting face of a roadway rising 1 in 6: a usual Warwickshire inclination.

Mr. A. Hall, replying to the remarks of Mr. Abell, said that the loss of pressure in transmission was somewhat difficult to calculate. The initial pressure at the air-receiver on the surface varied from 50 to 60 pounds per square inch, and the pressure was reduced to less than 40 pounds and possibly 35 pounds at the machine in the pit, a mile in-bye. At any rate, he thought that the useful effect obtained was not at any time much less than 50 per cent. He (Mr. Hall) had seen several in-bye air-compressors at work and he was very favourably impressed with them, but he thought that the application of an air-receiver of ample dimensions would enable better results to be obtained than those that he had witnessed. The heading-machines were placed comparatively close to the air-compressor, and it seemed to him that when two heading-machines were running the compressor was too quickly sucked empty. He (Mr. Hall) appreciated the views of Mr. Abell respecting the future possibilities and increased advantages of the use of in-bye air-compressors; and he was also in complete agreement with Mr. Abell as to the desirability of employing pipes of as large a diameter as practicable, consistently, of course, with economy and capital-cost.

He (Mr. Hall) agreed, to some extent, with the use of single-heading machines in the circumstances detailed by Mr. Hewitt, but in sufficiently hard coal, as in the Derbyshire seams referred to, he would prefer to use the double-heading machine to drive a wide heading, as it provided sufficient space for a double tram-line, more room to get about, and, at the same time, a greater percentage of round coal was produced, without appreciably diminishing the distance cut. The quantity of free air that would issue from a tap, ½ inch in diameter, at a pressure of 40 pounds per square inch, worked out by Napier's formula,

was 221 cubic feet per minute. In an anemometer-test recently made in the mine, a tap, with a circular bore, $\frac{3}{8}$ inch in diameter, at a pressure of 45 pounds per square inch, delivered 181 cubic feet of air per minute. He (Mr. Hall) could state that the air in headings ventilated in this manner was purer and clearer than many ventilated by means of either air-pipes, or brattice-cloth, or both. The size of the tap could, however, be increased so as to give any reasonable quantity of air. Mr. Hewitt's statement that the chargeman frequently neglected to leave open the small tap was purely a question of discipline in the mine, and, in his experience, on only one occasion had he known the chargeman to neglect to open the small tap, when the machine was standing, and unfortunately that happened on an occasion when Mr. Hewitt was inspecting the mine. With regard to the difficulty of keeping a machine weighing 6 tons up to its work, when cutting uphill, at a gradient of 1 in 6, it should be remembered that the frame and the engine of the machine did not travel as the cut advanced, and the arm and threaded shaft did not move forward when the frame was advanced. A steel-girder, placed across the heading, and supported by recesses cut in the sides, would take the weight of the shafts, whilst the frame was being pushed forward into position for the next cutting. So far as Warwickshire was concerned, however, the hills were usually driven to the dip: a gradient to the rise such as that mentioned by Mr. Hewitt being usually worked by jigs, and [redacted]

at 1s. per ton, and the actual difference in the average selling price. The average selling prices of 5s. 10¼d. and 5s. 7½d. were correct, and showed a saving of 2¾d. per ton on the whole output: the reduction in working cost, 25,200 tons at 1s. per ton, represented £1,250; the 25,200 tons of nut-slack at 4s. per ton, realized a further gain of £5,000; making a total gain of £6.250. That amount was very nearly the same figure as that recorded in his paper, £6,450; and a slight addition to the value of 4s. per ton would make the figures correspond exactly. He (Mr. Longden) believed that the best smoke-consumer was the underfeed stoker, and the maker told him that the only method which he feared was hand-firing. He was pleased to note that two other speakers had corroborated what he stated—that hand-firing with plenty of boilers was equal to any mechanical stoker. Mr. Laverick would find all particulars of the trellis-firebrick-work under the boilers, in his former paper.* This method of superheating the steam had been in operation at the Blackwell collieries for thirty years, effecting a saving of 20 per cent. in the consumption of coal. It had been tested with five boilers at the B winnings: without superheating, five boilers were required; and when superheating was in use, the work could be satisfactorily performed with four boilers. It was, he admitted, only a rough-and-ready test, but it was fairly accurate, and it extended over a long period. Many of the boilers which he put down in 1872 were there still, so that they had not been much injured. There was some doubt as to whether the soot would become red-hot and injure the plates, but it had not happened yet.

Mr. G. ALFRED LEWIS (Derby) wrote that, whilst he thoroughly appreciated the importance of economy in coal-consumption, he could not agree with Mr. Longden's method of estimating the saving effected. It appeared to him that a fallacy existed in the reasoning, and the weak point in the argument was that, with the original small output of 283,000 tons, 7½ per cent. was of inferior quality and was sent to the boilers; but when the output was increased to 586,000 tons, only 3 per cent. was of the low value. This might possibly have been the case, but the cause would be better discipline in the pit, and

* "The Evaporative Power of Lancashire Boilers," *Transactions of The Midland Counties Institution of Engineers*, 1876, vol. iv., page 22.

possibly different conditions of working, wherefore the improvement should not be credited to lessened consumption. By that assumption Mr. Longden showed an improvement in selling prices, and that difference was the measure of the advantage gained. It was easily shewn if $7\frac{1}{2}$ per cent. of any tonnage of coal was worth, say, 4s. per ton, whether it was burnt or sold, and the remainder was worth 6s. per ton, that the average value of the total was [$(7\frac{1}{2} \times 4) + (92\frac{1}{2} \times 6) \div 100$ or] 5s. 10·2d. per ton: and this value was the same whatever the output might be, and so the advantage shown by Mr. Longden vanished. Undoubtedly a great saving was effected, however, but he considered that it would better shewn by giving statistics as to the number of extra boilers, firemen, repairs, etc., that would have been necessitated had the consumption been maintained at the original amount of $7\frac{1}{2}$ per cent.

Mr. J. A. Longden said that 1s. per ton was taken as the usual value for colliery-consumption, but he did not assert that it was the real value of the coal. It was the fact that 25,000 tons of nut-slack were placed in a position to be sold at a price of 4s. per ton. He did not say that the figures were absolutely and literally correct; he thought that the particulars might be interesting to the members, and he wanted to bring out the different methods of calculating the cost. The difference in the average selling-price when, perhaps, 50 per cent. more coal was got in one week than in another was most marked: the [redacted]

The President (Mr. W. G. Phillips) said that he saw the force of Mr. Longden's explanation and reasoning, and where there had been some misapprehension about his points. He (Mr. Phillips) had always maintained that hand-firing well-done was better than machine-firing.

DISCUSSION OF MR. A. J. TONGE'S PAPER ON "UNGERGROUND FANS AS MAIN VENTILATORS."*

Mr. A. H. Stokes (H.M. Inspector of Mines, Derby) wrote that the idea of placing a fan underground was not new, for a ventilating fan fixed underground had worked for many years at a large mine in Nottinghamshire, but such fan was an auxiliary fan to assist the ventilation, and not the main ventilating fan. There was a large fan on the surface which did away with any objection arising under the Coal-mines Regulation Act. Mr. Tonge's idea was that underground fans should not be secondary or supplementary fans, but that they should do the whole of the ventilation of the mine or seam, and this led to the consideration whether such an arrangement could be legally sanctioned. The third General Rule of the Coal-mines Regulation Act required the fan to "be in such position and placed under such conditions as will tend to insure its being uninjured by an explosion." Could a mining engineer successfully hold that a fan placed underground, either in a main or a side road, was not in a place which tended to its injury in case of an explosion? The air of the mine would have to pass direct to the fan, and would not the track of an explosion also pass as direct as the air-current? Experience showed that fans on the surface had been so fixed as to escape injury, or to receive only slight injury by an explosion. In any case, they were under the immediate control of workmen, and could be repaired with freedom from noxious gases. Explosions were no respecter of either human life or property belowground. It was essential, after an explosion, that the fan should be available with as little delay as possible. In Mr. Tonge's case, the cables might be broken, the fan shattered, and the shafts for a time blocked to all ingress or egress to the mine. Was not a fan on the surface

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 207.

free from these disadvantages, if properly erected, and immediately available? It was stated that one advantage was an open shaft at the top, but this could equally be obtained by a fan on the surface, provided that the headgear was boxed in and the inlet and outlet for men and tubs passed through enclosed roadways with doors, leaving the shaft-top open so far as the cages and bankings were concerned; but it was pointed out that with such an arrangement of closed headgear and double doors there was considerable loss of air due to leakage. That was true, but the leakage kept the pit-top sweet and healthy for persons working inside the covered way: it was a small scale of air passing into the fan-drift. It was surprising how some managers would complain of a small leakage at the pit-top, whereas various large leakages through defective coursing of the air-current in the mine were, he was afraid, frequently ignored. Such managers should measure the quantity of air passing into the mine, and then measure the air passing through the first working-place on the intake side: the leakage would probably surprize many, and find employment for their skill in remedying the defect.

The suggestion was made that, in large mines, such fans might be fixed at some distance in the mine and utilized for pushing on the ventilation. There was one such fan now working in the Midland district. It was fixed about a mile from the shaft, but its utility had not proved equal to expectation.

The question of economy was raised, but he failed to see [redacted]

gauge of $\frac{7}{8}$ inch, B mine with $1\frac{5}{8}$ inches, and C mine with $1\frac{7}{8}$ inches. Between B and C mines, there was only $\frac{1}{4}$ inch of water-gauge, and the volumes were 50,000 and 45,000 cubic feet per minute respectively. The A mine was evidently a small mine, for there was only a volume of 18,000 cubic feet per minute. Were there not many mines having large splits of air with greater variations in the water-gauge? The logical conclusion was that there should be an underground fan for every split or variation of water-gauge, if Mr. Tonge's ideal was to be reached. It would be interesting to know why Mr. Tonge did not make his comparative calculations upon the actual figures from his own mine, rather than assume a hypothetical standard of five seams having such an extreme variation of water-gauge. It was more acceptable to base calculations upon actual facts, rather than upon an assumed basis which might or might not have its parallel in existence.

The figures recorded in Table I. were interesting, and if he correctly understood them under "present conditions" a total of 69 brake-horsepower appeared to be giving 113,000 cubic feet of air per minute, whereas under "anticipated conditions" a total of 125 brake-horsepower would give 138,500 cubic feet of air per minute, an increase of only 25,500 cubic feet of air for the expenditure of an additional 56 horsepower by the motors.

He (Mr. Stokes) trusted that any engineer who contemplated following the plan described by Mr. Tonge, would erect a main ventilating fan on the surface, in a position as far as possible to secure it from injury by an explosion, and should he afterwards desire to use auxiliary fans belowground he should provide that there was always an attendant in charge.

Mr. A. J. Tonge wrote that he was pleased to have an opportunity of replying to Mr. Stokes' remarks respecting "auxiliary fans." Mr. Stokes referred to a large colliery, where there was a fan fixed at the surface, and an auxiliary fan fixed underground that had been at work for many years. This arrangement appeared to have Mr. Stokes' approval; while the system referred to in his (Mr. Tonge's) paper met with some disapproval, both as regarded the legality and the power of re-entering the mine after an explosion. He (Mr. Tonge) would simply lay the two systems alongside of each other, and he thought that there could be no

doubt as to which would prove the most effective even after an explosion:—(*a*) In Mr. Stokes' example, there was a surface fan and an auxiliary fan fixed underground; and (*b*) in the system suggested by the writer, there were one or more main underground fans and a main surface fan.

After a supposed explosion, let it be assumed that the underground fans in both cases were temporarily put out of action. Under the system referred to by Mr. Stokes, the surface fan was repaired, if necessary, and again set to work; but the ventilation would not be as effective as before, owing to the loss of the underground fan, which, one must presume, had been a necessity for the full requirements of the mine. Under the system referred to in his (Mr. Tonge's) paper, and assuming the underground fan to be placed out of action, the surface fan was put to work and was sufficiently large to deal with the whole of the ventilation. In other words, where the system comprized "a surface fan with auxiliary fans," there was a condition of things in which each fan formed a part of the whole, and the ventilation was incomplete unless all the fans were at work together; in the system of "underground fans as main ventilators" there were two complete installations, the underground fans, capable of dealing with the whole of the ventilation while under ordinary working conditions, and the surface fan acting as a complete standbye for emergencies and commanding the whole range of the work.

He (Mr. Tonge) felt assured that Mr. Stokes, whom he never-

[redacted]

large mines, but that did not preclude meeting the requirements half way by putting one in each mine: more especially as one great source of loss was at the pit-top, and the double purpose of economizing air and facilitating work was served.

The paper could not possibly cover the whole ground, neither did it suggest that all mines were suitable for the double system; but it set forth a practical remedy for difficulties in many collieries, and the system attained its highest economy in deep seams of extensive area and high resistance, and where winding operations were conducted in the upcast-shaft.

DISCUSSION OF MR. CHARLES LATHAM'S "NOTES ON THE DETECTION AND ESTIMATION OF INFLAMMABLE GASES IN MINES BY MEANS OF FLAME-CAPS."*

Mr. A. H. STOKES (H.M. Inspector of Mines, Derby) wrote that the question raised by Mr. Latham was one of considerable importance, although it was treated more in the style of professional accuracy than practical management. But few could complain of Mr. Latham's high standard, namely:—The air must be free from fire-damp or safety-lamps must be used, and the air-current must be tested down to 0·25 per cent.: a percentage in which it was quite safe (so far as gas was concerned) to work with a naked light. It was to be hoped that Mr. Latham might some day see that standard legalized, for it would probably secure a clean sheet from little explosions in the present naked-light pits: those little "pin-prick" description of explosions, generally discreditable to all connected with them. But if he descended from the professional to the practical, it must be recognized that the law now required the amount of ventilation passing through the mine to be periodically measured and recorded, also the condition thereof, so far as the presence of gas as shown by the ordinary safety-lamp test. If a record of the quantity was necessary, why not the quality of the ventilation? Surely one was as important as the other, and now that there were lamps which would fairly accurately give the information down to 0·5 per cent. of gas, when placed in trained hands, there should be no difficulty in recording the quality as well as the

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 136.

quantity when the periodical test was made. Personally, he would say that any lamp clearly indicating 0·5 per cent. was quite sufficient for all mining purposes, at least if the fire-damp in the atmosphere was below 0·5 per cent. it might be ignored for all practical purposes. Upon reference to Table V.,* it would be seen that there was no variation in the height of flame-cap between 0·25 and 0·5 per cent., both percentages giving a flame-cap of 15 millimetres. How then was the person making the test able to discriminate whether the test should be recorded as 0·25 or 0·5 per cent? Even the adapter of the lamp could only see a difference of 1 millimetre or 0·040 inch between 0·25 and 0·5 per cent., and this was practically undistinguishable in the mine. It was of little use having any testing-lamp which would not give an indication such as could be read or understood by an ordinary observer. Laboratory-tests and professional readings of gas-caps were scientifically good, but the mine-test must be such as a mine-official could use with safety, and read with ease and accuracy.

With respect to the heat of the hydrogen-flame, Mr. R. McLaren had pointed out that "the extreme heat had the effect of burning the gauze."† He (Mr. Stokes) had a copper-gauze, in which a hole had been burnt, owing to the incautious use of the hydrogen-flame, but this danger had apparently now been obviated by the introduction of a stop-pin and steel-wire gauze.

The standard at present used in mines was the flame of an [redacted]

THE INSTITUTION OF MINING ENGINEERS.

SEVENTEENTH ANNUAL GENERAL MEETING,
HELD IN THE GRAND HOTEL, HANLEY, SEPTEMBER 12TH, 1906.

SIR LEES KNOWLES, BART., PRESIDENT, IN THE CHAIR.

Mr. A. M. HENSHAW (Past-President of the North Staffordshire Institute of Mining and Mechanical Engineers) offered a cordial welcome to the members. It was some years since The Institution of Mining Engineers had visited their district; the recollections of the members would be pleasant ones, and he hoped that the pleasure would be exceeded on this occasion, as an interesting programme of visits to works had been arranged.

ELECTION OF OFFICERS, 1906-1907.

The SECRETARY announced the election of officers for the ensuing year by the Council as follows:—

PRESIDENT:
MR. MAURICE DEACON.

VICE-PRESIDENTS:

MR. THOMAS DOUGLAS.	MR. T. W. H. MITCHELL.	MR. J. B. SIMPSON.
MR. J. T. FORGIE.	MR. R. T. MOORE.	MR. J. G. WEEKS.
MR. W. B. M. JACKSON.	MR. JOHN NEWTON.	MR. R. S. WILLIAMSON.
MR. R. MCLAREN.	MR. W. G. PHILLIPS.	MR. J. R. R. WILSON.
MR. J. H. MERIVALE.	MR. C. PILKINGTON.	MR. W. O. WOOD.

AUDITORS:
MESSRS. JOHN G. BENSON AND SONS, Newcastle-upon-Tyne.

TREASURERS:
MESSRS. LAMBTON & COMPANY, The Bank, Newcastle-upon-Tyne.

Mr. W. H. CHAMBERS moved a vote of thanks to the retiring President, Vice-Presidents, Councillors and Officers for their services during the past year.

Mr. PHILIP KIRKUP seconded the resolution, which was cordially adopted.

The SECRETARY read the Annual Report of the Council as follows:—

SEVENTEENTH ANNUAL REPORT OF THE COUNCIL.

The Council report with regret the death of Mr. George Lewis, a Past-president, and for many years a member of their body.

The societies forming The Institution of Mining Engineers continue as before: namely, the Manchester Geological and Mining Society; the Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and Warwickshire Institute of Mining Engineers.

The following table exhibits the progress of the membership since the formation of the Institution in 1889:—

Year ending July 31st.	No. of Honorary Members.	No. of Members.	No. of Non-federated.	Totals.
1890	0	1,189	50	1,239
1891	0	1,187	9	1,196
1892	14	1,401	19	1,434
1893	14	1,519	19	1,552
1894	13	2,055	123	2,191
1895	13	2,197	109	2,319
1896	13	2,288	81	2,382

[redacted]

Although these two meetings secured the attendance of a considerable number of members, the Council urge all members to endeavour to take part in the proceedings of the General Meetings. The influence of the Institution would thus become more effective, and the value of the *Transactions* would be greatly enhanced by the additional discussions which the papers read at the meetings would secure.

The attention of the members may be directed to the value of the *Transactions* containing, in addition to the reports of the proceedings of the meetings of The Institution of Mining Engineers, the proceedings of the seven federated societies; and, if this fact were made known to non-members, an increased membership of the Institution would follow.

Prof. H. Louis represented the Institution on the committee appointed by the Council of the Institution of Civil Engineers to consider the "Education and Training of Engineers."* The thanks of the members has been accorded to Prof. Louis for his services. The attention of the members is particularly drawn to the recommendations of the Committee.

Prizes have been awarded to the writers of the following papers, which are printed in the *Transactions* (vols. xxviii. and xxix.):—

- "The Conveyor-system for Filling at the Coal-face, as practised in Great Britain and America." By Messrs. W. C. Blackett and R. G. Ware.
- "The Occurrence of Underground Fires at the Greta Colliery, New South Wales." By Mr. Joshua Jeffries.
- "Mine-surveying Instruments." By Mr. Dunbar D. Scott.
- "The Development of Explosives for Coal-mines." By Mr. Donald M. D. Stuart.

Addresses have been delivered during the year by Sir Lees Knowles, Bart., President of The Institution of Mining Engineers; by Mr. Henry Bramall, President of the Manchester Geological and Mining Society; by Mr. W. G. Phillips, President of the Midland Counties Institution of Engineers; by Mr. A. H. Heath, President of the North Staffordshire Institute of Mining and Mechanical Engineers; and by Mr. W. N. Atkinson, President of the South Staffordshire and Warwickshire Institute of Mining Engineers.

* *Trans. Inst. M. E.*, 1906, vol. xxx., page 485.

The papers on geology include the following:—

"The Leading Features of the Lancashire Coal-field." By Mr. Joseph Dickinson.

"The Mining Fields of Southern Rhodesia in 1905." By Prof. J. W. Gregory.

"Corundum in Ontario, Canada: Its Occurrence, Working, Milling, Concentration and Preparation for the Market as an Abrasive." By Mr. D. G. Kerr.

"The Gold-field of Paracatú, Minas Geraes, Brazil." By Mr. Hugh Pearson.

"Petroleum-occurrences in the Orange River Colony." By Mr. A. R. Sawyer.

"The Value of Fossil Mollusca in Coal-measure Stratigraphy." By Mr. John T. Stobbs.

"The Barton and Forcett Limestone-quarries." By Mr. Thomas Teasdale.

"Geological Notes on Sinking Langsett and Underbank Concrete-trenches in the Little Don Valley." By Mr. William Watts.

Mining engineering has been the subject of the following papers:—

"The Application of Direct Cementation in Shaft-sinking." By Mr. C. Dinoire.

"Considerations on Deep-mining." By Mr. George Farmer.

"The Mining Fields of Southern Rhodesia in 1905." By Prof. J. W. Gregory.

"The Great Planes of Strain in the Absolute Roof of Mines." By Mr. H. W. G. Halbaum.

"An Acount of Sinking and Tubbing at Methley Junction Colliery, with a Description of a Cast-iron Dam to resist an Outburst of Water." By Mr. Isaac Hodges.

"The Gold-field of Paracatú, Minas Geraes, Brazil." By Mr. Hugh

[redacted]

"Non-rotating Wire-ropes, and Tests of Wire-rope Attachments." By Mr. Ernest King.

"Colliery-consumption." By Mr. J. A. Longden.

"A Spark-arrester for Locomotives." By Mr. William Maurice.

"Further Notes on Capels for Winding-ropes." By Mr. T. W. H. Mitchell.

"The Unwatering of the Achddu Colliery, with a Description of the Riedler Express Pump." By Mr. John Morris.

"Commercial Possibilities of Electric Winding for Main Shafts and Auxiliary Work." By Mr. W. C. Mountain.

"The Two-stage Air-compressing Plant at Teversal Collieries." By Mr. Jonathon Piggford.

"The Tangye Suction Gas-producer." By Mr. C. H. Treglown.

"Proposed Plant for Winding 250 Tons of Coal per Hour from a Depth of 3,000 Feet." By Mr. B. Woodworth.

Electricity and its applications have been discussed in the following papers:—

"Electric Power-station, Winding-gear and Pumping-plant of the Tarbrax Oil Company, Limited." By Mr. James Caldwell.

"Coal-cutting Machines of the Bar Type." By Mr. William Charlton.

"The Use of Electricity in Collieries." By Mr. P. Barrett Coulston.

"A Mechanical Coal-cutter in Queensland." By Mr. William Fryar.

"Electrical Power-distribution." By Mr. Robert Loraine Gamlen.

"The Generation of Electricity by the Waste Gases of Modern Coke-ovens." By Mr. Gerald H. J. Hooghwinkel.

"Practical Problems of Machine-mining." By Mr. Sam Mavor.

"Commercial Possibilities of Electric Winding for Main Shafts and Auxiliary Work." By Mr. W. C. Mountain.

"Electrically-driven Air-compressors combined with the Working of Ingersoll-Sergeant Heading-machines, and the Subsequent Working of the Busty Seam at Ouston Colliery." By Mr. A. Thompson.

"Earth in Collieries, with Reference to the 'Special Rules for the Installation and Use of Electricity.'" By Mr. Sydney F. Walker.

"The Capacity-current and its Effect on Leakage-indications on Three-phase Electrical Power-service." By Mr. Sydney F. Walker.

"Determination of the Specific Electrical Resistance of Coal, Ores, etc." By Mr. G. C. Wood.

The working of mining machines has been described in the following papers:—

"A Conveyor for Filling Coal at the Face." By Mr. Léon André.

"Coal-cutting Machines of the Bar Type." By Mr. William Charlton.

"A Mechanical Coal-cutter in Queensland." By Mr. William Fryar.

"The Stanley Double-heading Machine." By Mr. Arthur Hall.

"Practical Problems of Machine-mining." By Mr. Sam Mavor.

"Electrically-driven Air-compressors combined with the Working of Ingersoll-Sergeant Heading-machines, and the Subsequent Working of the Busty Seam at Ouston Colliery." By Mr. A. Thompson.

The education of engineers has been discussed in the following papers:—

"Education and Training of Engineers." Report of a Committee appointed by the Council of the Institution of Civil Engineers.
"The Education of Mining Engineers." By Prof. J. W. Gregory.
"Mining Education in the Victoria University of Manchester." By Mr. George H. Winstanley.

The occurrence of fires and the use of rescue-appliances have been described in the following papers:—

"A New Apparatus for Rescue-work in Mines." By Mr. W. E. Garforth.
"Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party." By Mr. G. A. Meyer.
"A Gob-fire in the Ten-feet Seam, North Staffordshire." By Mr. W. G. Peasegood.

The manufacture of coke and the utilization of the waste-heat of coke-ovens are described in the following papers:—

"Improved Dampers for Coke-oven Flues." By Mr. William Archer.
"'Black Ends:' their Cause, Cost and Cure." By Mr. T. Beach.
"The Generation of Electricity by the Waste Gases of Modern Coke-ovens." By Mr. Gerald H. J. Hooghwinkel.
"Bye-product Coke and Huessener Bye-product Coke-ovens." By Dr. J. A. Roelofsen.

The following papers have been contributed on mine ventilation, mine-gases and colliery explosions:—

"The Elba and Clydach Vale Colliery Explosions." By Mr. James [redacted]

The foregoing lists demonstrate the varied nature of the papers (64) communicated during the past year and printed in the *Transactions* (vols. xxx. and xxxi.). The Council trust that members will continue to send in papers as liberally as heretofore. During the past year, "Notes of Papers (93) on the Working of Mines, Metallurgy, etc., from the *Transactions* of Colonial and Foreign Societies and Colonial and Foreign Publications," have been continued and should prove of value to the members.

Mr. J. A. Longden represented the Institution at the meeting of Delegates of Corresponding Societies of the British Association for the Advance of Science held in London in 1905.

Members of The Institution of Mining Engineers may purchase copies, at privileged rates, of the *Transactions* of the following Corresponding Societies:—The Australasian Institute of Mining Engineers, the Canadian Mining Institute and the Mining Society of Nova Scotia.

The thanks of the members are due to the North of England Institute of Mining and Mechanical Engineers, who have provided, as hitherto, free of charges, offices and stock-rooms, and other facilities, during the past year.

BOOKS, ETC., ADDED TO THE LIBRARY.

Annales des Mines de Belgique, Bruxelles. Vol. x., No. 4; and vol. xi., Nos. 1-3.

British Association for the Advancement of Science, London. Report of the Seventy-fifth Meeting, held in South Africa in August and September, 1905.

British Society of Mining Students, Birmingham. Journal, vol. xxvii., Nos. 5 and 6.

Chemical and Metallurgical Society of South Africa, Johannesburg. Journal, vol. vi., Nos. 1-10.

Cory Brothers & Company, Limited, Cardiff. British Coal and Freight Circular and General Export List, May 31st, 1905, to July 31st, 1906.

Cuerpo de Ingenieros de Minas del Perú, Lima. Boletín, Nos. 24-36.

Engineering and Mining Journal, New York City. Vol. lxxx., Nos. 5-26; vol. lxxxi., Nos. 1-26; and vol. lxxxii., Nos. 1-5.

Engineering Times, London. Vol. xiv., Nos. 131-150; vol. xv., Nos. 151-177; and vol. xvi., Nos. 178-183.

Franklin Institute of the State of Pennsylvania, Philadelphia. Journal, vol. clx., Nos. 2-6; vol. clxi., Nos. 1-6; and vol. clxii., No. 1.

Institution of Mining and Metallurgy, London. Transactions, vol. xiv.

Massachusetts Institute of Technology, Society of Arts, Boston. Technology Quarterly, vol. xviii., Nos. 2-4; and vol. xix., No. 1.

Mining Society of Nova Scotia, Halifax. Transactions, vol. ix.
New South Wales, Department of Mines, Sydney. Annual Report, 1905.
—, Geological Survey, Sydney. Mineral Resources, No. 11.
—, —, —. Records, vol. viii., No. 2.
New Zealand, Department of Mines, Wellington. Annual Report, 1905.
Queensland, Department of Mines, Brisbane. Annual Report, 1905.
—, —, —. Year-book, 1906.
Queensland Government Mining Journal, Brisbane. Vol. vi., Nos. 61-67; and vol. vii., Nos. 68-72.
South Wales Institute of Engineers, Cardiff. Proceedings, vol. xxiv., Nos. 5-8.
United States, Geological Survey, Washington. Annual Reports, 1903-1904 and 1904-1905.
—, —, —. Bulletin, Nos. 242-274.
—, —, —. Mineral Resources of the United States, 1904.
—, —, —. Monographs, Nos. xlvii. and xlviii., and Atlas to accompany No. xxxii.
—, —, —. Professional Papers, Nos. 29-45.
—, —, —. Water-supply and Irrigation Papers, Nos. 119-154.
Western Australia, Geological Survey, Perth. Bulletin, Nos. 16-18 and 20.

EXCHANGES.

Annales des Mines de Belgique.
*Australasian Institute of Mining Engineers.
British Association for the Advancement of Science.
British Society of Mining Students.
*Canadian Mining Institute.
Chemical and Metallurgical Society of South Africa.
Cuerpo de Ingenieros de Minas del Perú.
Franklin Institute of the State of Pennsylvania.
*Geological Institution of the University of Upsala.
[redacted]

The Local Institutes in Account with The Institution of Mining Engineers, for the Year Ending July 31st, 1906.

Dr.

Dr.	No. of Members. Federated.	No. of Members. Non-federated.	Balance due at the beginning of the year. £ s. d.	Amounts falling due during the year. Calls made during the year. £ s. d.	Excerpts. £ s. d.	Transactions, etc. £ s. d.	Totals. £ s. d.
Manchester Geological and Mining Society	195	56	26 15 0	213 5 0	31 18 9	11 8 8	283 7 5
Midland Counties Institution of Engineers	357	...	22 5 0	339 3 0	0 5 6	17 19 5	379 12 11
Midland Institute of Mining, Civil and Mechanical Engineers	321	...	13 1 9	304 19 0	3 16 8	4 19 5	326 16 10
Mining Institute of Scotland	492	17	4 1 0	475 18 0	15 2 0	3 19 5	499 0 5
North of England Institute of Mining and Mechanical Engineers	1,335	...	88 8 0	1,268 5 0	32 19 0	62 7 5	1,451 19 5
North Staffordshire Institute of Mining and Mechanical Engineers	166	...	10 11 6	157 14 0	0 4 0	8 19 5	177 8 11
South Staffordshire and Warwickshire Institute of Mining Engineers...	106	...	47 4 3	100 14 0	0 0 0	4 19 5	152 17 8
Totals	2,972	73	212 6 6	2,859 18 0	84 5 11	114 13 2	3,271 3 7

Cr.

Cr.	Amounts paid during the year. Balance from previous years. £ s. d.	Calls. £ s. d.	Excerpts. £ s. d.	Transactions, etc. £ s. d.	Totals. £ s. d.	Balance due at July 31st, 1906. £ s. d.
Manchester Geological and Mining Society	26 15 0	143 15 0	12 16 3	2 5 9	185 12 0	97 15 5
Midland Counties Institution of Engineers	22 5 0	325 17 0	0 5 6	17 19 5	366 6 11	13 6 0
Midland Institute of Mining, Civil and Mechanical Engineers	13 1 9	300 4 0	3 16 8	4 19 5	322 1 10	4 15 0
Mining Institute of Scotland	4 1 0	473 1 0	15 2 0	3 19 5	496 3 5	2 17 0
North of England Institute of Mining and Mechanical Engineers	88 8 0	1,149 10 0	32 19 0	58 7 5	1,329 4 5	122 15 0
North Staffordshire Institute of Mining and Mechanical Engineers	10 11 6	133 19 0	0 4 0	8 19 5	153 13 11	23 15 0
South Staffordshire and Warwickshire Institute of Mining Engineers	45 6 3	47 10 0	0 0 0	0 5 9	93 2 0	59 15 8
Totals	210 8 6	2,573 16 0	65 3 5	96 16 7	2,946 4 6	324 19 1

Dr. THE TREASURERS IN ACCOUNT WITH
FOR THE YEAR

	£	s.	d.	£	s.	d.
July 31, 1905.						
To Investment with River Tyne Commission	1,000	0	0			
„ Balance at Bank, Current Account	426	17	5			
„ „ „ Deposit Account	111	13	9			
„ „ in Cashier's hands	0	8	10			
				1,539	0	0
July 31, 1906.						
To Subscriptions for the Year ending July 31st, 1904—						
Federated—						
South Staffordshire and Warwickshire Institute of Mining Engineers	2	17	0			
				2	17	0
To Subscriptions for the Year ending July 31st, 1905—						
Federated—						
Manchester Geological and Mining Society	23	15	0			
Midland Counties Institution of Engineers	14	5	0			
Midland Institute of Mining, Civil and Mechanical Engineers	13	1	9			
Mining Institute of Scotland	1	18	0			
North of England Institute of Mining and Mechanical Engineers	87	8	0			
North Staffordshire Institute of Mining and Mechanical Engineers	9	10	0			
South Staffordshire and Warwickshire Institute of Mining Engineers	35	3	0			
				185	0	9
Non-federated—						
Manchester Geological and Mining Society	3	0	0			
				3	0	0
To Subscriptions for the Year ending July 31st, 1906—						
Federated—						

[redacted]

THE INSTITUTION OF MINING ENGINEERS. **Cr.**
ENDING JULY 31, 1906.

July 31, 1906.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
By Printing—												
Transactions, vol. xxvii., printing	40	10	9									
" " " plates ...	4	3	0									
				44	13	9						
" " xxviii., printing	123	16	4									
" " " plates ...	0	14	2									
				124	10	6						
" " xxix., printing	384	2	8									
" " " plates ...	106	6	3									
				490	8	11						
" " xxx., printing	404	12	8									
" " " plates ...	75	11	0									
				480	3	8						
" " xxxi., printing	219	4	6									
" " " plates ...	35	2	7									
				254	7	1						
" " xxxii., plates ...	2	8	0									
				2	8	0						
							1,396	11	1			
Excerpts, vol. xxvii.				23	5	5						
" " xxviii.				5	10	0						
" " xxix.				46	17	11						
" " xxx.				47	8	1						
" " xxxi.				25	2	6						
							148	3	11			
Proofs of Papers for General Meetings							7	0	11			
Circulars							14	18	6			
										1,566	15	3
" Addressing *Transactions*, etc.							47	10	5			
" Stamps—Circulars				8	11	5						
" " Correspondence				25	7	10						
" " *Transactions*				410	16	11						
							444	16	2			
" Stationery, etc.							100	16	9			
" Insurance of *Transactions*							3	0	0			
" Binding—Library				3	2	3						
" " Sundries...				0	5	0						
" " *Transactions*				11	13	0						
							15	0	3			
" Reporting of General Meetings							16	16	0			
" Expenses of General Meetings							15	1	9			
" Incidental Expenses							18	10	2			
Carried forward							£661	11	6	£1,566	15	3

Dr. THE TREASURERS IN ACCOUNT WITH

	1904-1905. £	s.	d.	1905-1906. £	s.	d.	£	s.	d.
Brought forward							4,303	13	9
To Local Publications and Authors' Copies—									
The Institution of Mining Engineers	17	16	6	46	10	11			
Manchester Geological and Mining Society ...	0	0	0	12	16	3			
Midland Counties Institution of Engineers ...	0	0	0	0	5	6			
Midland Institute of Mining, Civil and Mechanical Engineers	0	0	0	3	16	8			
Mining Institute of Scotland	2	3	0	15	2	0			
North of England Institute of Mining and Mechanical Engineers	0	0	0	32	19	0			
North Staffordshire Institute of Mining and Mechanical Engineers	1	1	6	0	4	0			
South Staffordshire and Warwickshire Institute of Mining Engineers	4	6	3	0	0	0			
	25	7	3	111	14	4			
							137	1	7

	1904-1905. £	s.	d.	1905-1906. £	s.	d.
To Sales of Transactions, etc.—						
The Institution of Mining Engineers	0	0	0	122	4	9
Manchester Geological and Mining Society ...	0	0	0	2	5	9
Midland Counties Institution of Engineers ...	8	0	0	17	19	5
Midland Institute of Mining, Civil and Mechanical Engineers	0	0	0	4	19	5
Mining Institute of Scotland	0	0	0	3	19	5
North of England Institute of Mining and Mechanical Engineers	1	0	0	58	7	5
North Staffordshire Institute of Mining and						

[redacted]

THE INSTITUTION OF MINING ENGINEERS.—*Continued.* **Cr.**

	£	s.	d.	£	s.	d.
Brought forward	661	11	6	1,566	15	3
By Salaries, Wages, Auditing, etc.	784	7	0			
„ Indexing *Transactions*	20	0	0			
„ Travelling Expenses	28	15	8			
				1,494	14	2
„ Translation of Papers	6	0	0			
„ Abstracts of Foreign Papers, vol. xxviii.	31	0	6			
„ Barometer Readings, etc.	7	3	6			
„ Calendars	17	17	6			
„ Prizes for Papers in vols. xxvi., xxvii., xxviii. and xxix.	45	0	0			
				107	1	6
				3,168	10	11
„ Adjustment of Excerpts:—						
Mining Institute of Scotland	1	16	6			
				1	16	6
„ Investment with River Tyne Commission	1,000	0	0			
„ Balance at Bank, Current Account	170	17	5			
„ „ „ Deposit Account, including Interest	731	6	1			
„ „ in Cashier's hands	5	7	3			
				1,907	10	9
				£5,077	18	2

We have examined the above accounts of receipts and payments, with the books and vouchers relating thereto, and certify that in our opinion it is correct.

JOHN G. BENSON & SONS,
Chartered Accountants.

Newcastle-upon-Tyne,
August 14th, 1906.

THE INSTITUTION OF
BALANCE SHEET.—

Liabilities.

July 31, 1906.	£	s.	d.	£	s.	d.
Sundry Creditors—						
Advertizements paid in Advance	5	16	3			
Printing, etc.	1,376	10	11			
Postage of Transactions	210	0	0			
Abstracts of Foreign Papers in Volumes xxix., xxx. and xxxi.	93	15	0			
Barometer Readings	8	0	0			
Prizes for Papers in Volumes xxviii., xxix., xxx. and xxxi.	45	0	0			
Indexing Volumes xxviii., xxix., xxx. and xxxi. ...	80	0	0			
				1,819	2	2
Balance of Assets over Liabilities, exclusive of the Value of the Stock of *Transactions*, etc.				684	16	6

MINING ENGINEERS.
JULY 31, 1906.

Assets.

July 31, 1906.	£ s. d.	£ s. d.
Balance at Bank, Current Account	170 17 5	
" " Deposit Account, including Interest	731 6 1	
" in Cashier's hands	5 7 3	
Investment with River Tyne Commission	1,000 0 0	
" " " , Interest to date	11 2 9	
		1,918 13 6
Subscriptions for the Year ending July 31, 1905, Unpaid—		
Federated—		
South Staffordshire and Warwickshire Institute of Mining Engineers	1 18 0	
		1 18 0
Non-federated—		
Manchester Geological and Mining Society	9 0 0	
		9 0 0
Subscriptions for the Year ending July 31, 1906, Unpaid—		
Federated—		
Manchester Geological and Mining Society	66 10 0	
Midland Counties Institution of Engineers	13 6 0	
Midland Institute of Mining, Civil and Mechanical Engineers	4 15 0	
Mining Institute of Scotland	2 17 0	
North of England Institute of Mining and Mechanical Engineers	118 15 0	
North Staffordshire Institute of Mining and Mechanical Engineers	23 15 0	
South Staffordshire and Warwickshire Institute of Mining Engineers	53 4 0	
		283 2 0
Non-federated—		
Manchester Geological and Mining Society	3 0 0	
		3 0 0
Local Publications and Authors' Copies, Unpaid—		
Institution of Mining Engineers	1 3 10	
Manchester Geological and Mining Society	19 2 6	
		20 6 4
Transactions Sold, Unpaid—		
Institution of Mining Engineers	3 9 0	
Manchester Geological and Mining Society	0 2 11	
North of England Institute of Mining and Mechanical Engineers	4 0 0	
South Staffordshire and Warwickshire Institute of Mining Engineers	4 13 8	
		12 5 7
Advertizements, Unpaid		255 13 3
		£2,503 18 8

REPORT OF THE DELEGATE TO THE CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, YORK, 1906.

The report of Mr. J. A. Longden, representing the Institution, was read as follows:—

Stanton Iron-works,
Nottingham.
August 13th, 1906.

To the President and Council of
The Institution of Mining Engineers.

Gentlemen,

The meetings of Delegates to the British Association for the Advancement of Science appointed by the local Societies, were held at York on August 2nd and 7th, 1906. I regret that I found myself unable to attend the meeting on the first day, but I was present at that which was held on the second day.

The meeting was presided over by Sir Edward William Brabrook, who delivered an address.

The desirability of promoting county photographic surveys was introduced by Mr. W. Jerome Harrison, and carefully considered, but there was a general feeling that the Geological Section were already dealing with this matter so efficiently that it would not be advisable to interfere in any way with their existing arrangements. A committee of five was appointed to meet at Leicester next year, and bring the subject up again at the Conference of Delegates.

Much consideration has been given by the meeting to the subject of railway-rates, in order to ascertain whether any steps could be taken to secure reduced rates, under certain circumstances, for members of the Corresponding Societies. Consider-

[redacted]

A NEW POCKET-TRANSIT.

BY W. DENHAM VERSCHOYLE.

The instrument, which is the subject of the following notes, was developed actually in practice and offers a solution of many of the difficulties that occur in using the instruments at present on the market. In making a magnetic survey with any instrument, either underground or overground, of course the local magnetic currents must cause slight inaccuracies and this instrument does not propose to eliminate these; but, for simplifying

FIG. 1.—POCKET TRANSIT: READY FOR USE.

the work where the use of this class of instrument is admissible, it has advantages which should commend it. To determine the magnetic bearing of a line that terminates at a point which is elevated or depressed at a high angle above or below the point of observation, is not an easy matter with any pocket-instrument, and, when the point is almost vertically below or above that of observation, it becomes almost an impossibility with some of them. With this instrument, however, it makes no difference how high the vertical angle is; and the instrument has the added advantage that, whilst taking the magnetic bearing, the

vertical angle is also automatically recorded, one observation giving the two readings. For rapid topographical work or working in a constrained position, as often occurs in filling in details of stoping operations, this is a feature that will be appreciated.

Fig. 1 shows the instrument ready for use, and Fig. 2 as it appears when being carried in the pocket or in its case. Fig. 3 shows the principle upon which it is constructed; H is the magnetic needle to which is attached a scale, G, divided to ½ degree: not on the top as in the ordinary prismatic compass, but on a bevelled edge, which enables the figures to be seen through a circular window in the side of the compass-box. A ray of light then coming from any point, A, on the scale passes through the circular window and is brought back to the eye by a prism which is fixed to an arm, I, constructed to revolve through any angle about the centre of the window. An object, F, being brought into line with the cross-wires, at D, and the sight-hole, B, is easily discernible at the same moment that any figures, at A, are projected back to the retina.

[redacted]

The instrument can also be used as a clinometer, and a tripod, of special design, is provided for those who require it.

In working with the instrument, it is necessary to remember that the centre is at the point B, and not at the centre of the needle. It is easily demonstrable, then, that any horizontal angle through which the sight-line, CF, is moved, with B as the centre, is equal to the angle through which AB is revolved in the same movement with reference to the centre-point of the needle, the construction of the instrument being such that AB is always at right angles to CF (Fig. 3).

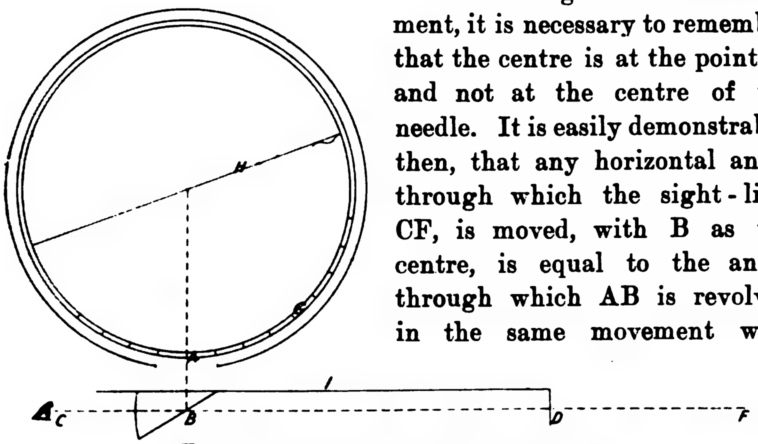

FIG. 3.—CONSTRUCTION OF POCKET TRANSIT.

The instrument is called the Verschoyle pocket-transit.

FIG. 4.—POCKET TRANSIT TAKING AN INCLINED BEARING.

Mr. Bennett H. Brough (London) said that the instrument was ingenious and useful, particularly for rapid and rough topographical surveys; but he thought that, when the instrument was used underground, considerable difficulties would there be encountered owing to insufficient light. He (Mr. Brough) had not been able to obtain satisfactory results with the prismatic compass when used underground, and this instrument, although called a pocket-transit, was really a combined prismatic compass and clinometer. Indeed, it was questionable whether the term "transit" was quite permissible. Prof. Henry Louis had invented an instrument with the same object in view, and in America the Brunton pocket-transit was widely used. The success of these compass-instruments suggested that there was a field for such a one as that described, and the ingenious way in which Mr. Verschoyle had solved the difficulty of being able to measure a very steep vertical angle seemed to deserve warm commendation.

Mr. H. Dean (Armstrong College, Newcastle-upon-Tyne) wrote that the means described, by which the bearings of lines, which lie at a considerable inclination to the horizontal plane, could be observed and their vertical angles recorded, certainly rendered the instrument capable of more general application than the ordinary prismatic compass. With regard to the arrangement by means of which increased distance between the sights was obtained, in order to enhance the accuracy of the in- [redacted]

struction it would certainly seem advisable to aim at throwing the errors as far as possible in the direction of the vertical rather than the horizontal angles.

Mr. W. D. Verschoyle, replying to the discussion, wrote that he thanked Mr. Bennett H. Brough for his kind remarks, but he ventured to differ with him on two points that he had raised. For working underground it would be found that it was merely a question of holding the light properly, to achieve perfect results so far as illumination was concerned. Thus, with a miner's lamp affixed to the cap, or with a fairly long candle held in the left hand, readings could be obtained with great facility, and this could be proved easily in a dark room. With reference to the use of the word "transit," he believed that this word was first applied by Roemer about 1690, to an instrument with only a vertical circle, and therefore its use to take the place of the word "theodolite," which was essentially an altazimuth instrument, might be correctly characterized as "loose." He would submit as a generalization, that any instrument the line of sight of which could be revolved along a vertical plane might be termed a "transit," and that this word was more correctly applicable where revolution in a horizontal plane was not contemplated. In the name of an instrument like this brevity was a good goal to aim at, and there was perhaps no single word in the language that would so nearly convey its general characteristics as the word "transit," a point which Mr. D. W. Brunton had also evidently realized. In the completed instrument, however, affixed to the tripod connections, there was a horizontal divided circle, which was so arranged that the eccentricity of the instrument was overcome. Whilst, therefore, capable of being used as a pocket-instrument, it could be fitted in a few seconds for making an angular survey. This part was, unfortunately, not yet ready for inspection.

The original design was along the lines suggested by Mr. Dean, but it was found impossible to obtain the required compactness. In the present design, compactness had been attained, and every part had been made so strong that only very rough usage would throw the instrument out of adjustment. The joints had a particularly long axis and long shoulders to butt against, so that, in the event of small indentations on any part of the bearing surface, there was still a large part perfectly true.

It was found by actual experiment that on filling both the joints with water and grit, such as might be found there in mine-surveying, the difference of two careful readings with and without the grit was inappreciable, but on filling up one joint with more grit than a careful surveyor would ordinarily have there, a difference of about ½ degree was observable. For these experiments, the body of the instrument was fixed immovably. In actual practice, however, if the theodolite confirmed a survey made with this class of instrument as within ½ degree he (Mr. Verschoyle) thought that the operator was to be congratulated, particularly if it had been done with a prismatic compass, the vertical depression or elevation being over 20 or 30 degrees. In mining and other work it frequently occurred that the vertical angle was quite as important as the horizontal, and it was a moot point whether it was not better to have absolute accuracy in one reading as in this instrument, than possible inaccuracy in both as in the suggested design, for it was almost a certainty that there would be a variable inaccuracy from personal or magnetic causes, in taking a magnetic reading with any instrument of this class.

The CHAIRMAN (Sir Lees Knowles, Bart.) moved a vote of thanks to Mr. Verschoyle for his description of a very useful instrument.

Mr. J. R. HAINES seconded the resolution, which was cordially approved.

[redacted]

GYPSUM, AND ITS OCCURRENCE IN THE DOVE VALLEY.

By T. TRAFFORD WYNNE.

Papers describing the occurrence of this mineral in Nottinghamshire* and in the North of England† have already been submitted to the Institution, but the deposits of the Dove valley have, the writer believes, not yet been described.

Occurrence.—Gypsum occurs very widely distributed over the world, especially in the vicinity of deposits of rock-salt, although much more rarely under workable conditions.

In England, it is found in the marls overlying the salt-deposits of Cheshire, Worcestershire, Durham and Staffordshire. The Chartley mine, worked on an extensive scale some years ago, is in close proximity to the present salt-wells near Stafford. The workable deposits in England, extending from the Eden valley, near Carlisle, to Battle in Sussex, lie near a line drawn between these two places.

It has also been worked on a small scale in Scotland and Ireland.

The writer has seen extensive deposits in Northern Persia, near the borders of the great salt-desert. It is there known as *gatch*. It is dug from shallow pits, burnt in rough-stone kilns, and is frequently used for lining the walls and roofs, and for covering the floors of the houses. It is soft and extremely white, and closely resembles the gypsum found in detached bodies, locally called "self pillars," found near the edges of the main deposits near Tutbury. The writer has also seen gypsum in Mexico and other countries.

History.—The history of the use of alabaster by sculptors, especially for monumental work and church-decoration, dates back to ancient times, and, so far as the writer can learn, the

* "The Gypsum-deposits of Nottinghamshire and Derbyshire," by Mr. A. T. Metcalfe, *Trans. Inst. M. E.*, 1896, vol. xii., page 107.

† "The Gypsum of the Eden Valley," by Mr. David Burns, *Trans. Inst. M. E.*, 1903, vol. xxv., page 411.

whole of the stone so used came from mines lying between Tutbury castle and the site of the present Fauld mines.

"The Register of John of Gaunt," now in the office of the Duchy of Lancaster, records that a monument was erected by John of Gaunt, Duke of Lancaster, to the memory of his Duchess in St. Paul's Cathedral in 1363: the chief material being alabaster sent from Tutbury, and the cost, including carriage, was £486.

At an earlier date than this, alabaster was largely used in the archway of the great western doorway of Tutbury church, commenced in 1080. This shews that its use in sculpture dates back to the Norman conquest; and it was probably well known in France at an even earlier date. The use for monumental purposes is also shown by the fact that when Tutbury church was restored, in the early part of the last century, several large alabaster slabs were found with inscriptions dating from 1622 to 1681.

As far back as 1371, the great centres of the trade in alabaster were Burton-upon-Trent, Nottingham and York. The smaller pieces were apparently supplied from Chellaston in Derbyshire; but, as at present, when large blocks were required they were obtained from Tutbury.

On the small hills in the vicinity of Castle Hayes, between Tutbury and Fauld, may still be seen the remains of shallow excavations from which the blocks of alabaster were extracted in the past. These blocks do not appear to have been portions of [redacted]

extracted from Messrs. J. C. Staton & Company's mine at Fauld, and sent to be used in the New York palace of Mr. J. K. Vanderbilt.

Dr. Robert Plot makes some interesting remarks respecting gypsum, when used for plaster-making.*

Composition and Varieties of Gypsum.—Gypsum or sulphate of lime is composed of 32·6 per cent. of lime, 46·5 per cent. of sulphuric acid and 20·9 per cent. of water. Its specific gravity varies from 2·31 to 2·33. In a pure crystalline state, it is clear and translucent with a pearly lustre, but according to the degree with which it is mixed with other minerals it is grey, yellow, brown or black, and opaque. It crystallizes in right rhombic prisms with bevelled edges. The varieties comprise: (1) anhydrite or anhydrous sulphate of lime, containing 41·2 per cent. of lime and 58·8 per cent. of sulphuric acid; (2) fibrous gypsum, composed of fine white fibres; (3) radiated gypsum, having a radiated structure; (4) selenite, including foliated transparent gypsum; (5) snowy gypsum; and (6) alabaster, the massive form of gypsum.

Geology.—Sulphate of lime is found in most of the geological formations. The workable beds in the northern and midland

* Beside the Stones that serve the necessities of Mankind, there are others in this County that will serve to adorn, both his Buildings and his Person: such as Alabaster, wherewith the Chore at Lichfield, joyntly with Cannel-coal (as I noted before) is delicatly paved in imitation of Marble: as well indeed it may, rather with this than any thing else. . . . Of the latter sort whereof, I could hear of none in this County, that dug near Frodswell Hall (where there is a small vein fit only for flooring rooms, not thought worth the pursueing) and in Heylinds park, where too it was anciently gotten; being, as I was inform'd, as hard, as that which is gotten South of Marchington Church, which being likewise but of a courser kind, is prepared for making plaister for floors, seelings, and the walls of Needle-work houses. in this Method: First they lay on the ground a stratum of wood (which is best) or a load of wood and coal mixt together, upon which they pile as much rough Alabaster; then fireing the wood they let it burn together till 'tis out, which makes the Alabaster so soft and brittle, that it needs only thrashing to reduce it to powder, the greater parts whereof being separated from the smaller by a seive, the former mixt with water are used for flooring, and the finer for seeling and walling of Houses. When they lay their floors whether for dwelling or Moult-houses, they wet a whole tub full and throw it down together; but when they seel or parge with it, they wet it by degrees, which they call gageing; and in both cases lay it on, and spread it as fast as they can, for it hardens, (as Plaister of Paris) in a very little time: the Walls and Seelings made with it having this convenience, that they are presently sweet, having nothing of the ill smell of those made with Lime and hair; and the walls of their houses enduring like stone, if the plaister fall not out from between the Timber, as it sometimes does for want of grooving it round within side before the plaister be laid on; which if done, it enters the grooves whilst it is soft, and cannot any way fall out of them, when once it is hardened.—*The Natural History of Stafford-shire*, by Dr. Robert Plot, 1686, page 173.

counties of England are found in the New Red Marl or Upper Keuper division of the Trias. In Sussex, the deposit occurs in the Purbeck beds.

The method of deposition of these beds is a question which does not seem to have been as yet properly elucidated. Sir Archibald Geikie says: "The study of the precipitations which take place on the floors of modern salt-lakes is important in throwing light upon the history of a number of chemically-formed rocks. The salts in these waters accumulate until their point of saturation is reached, or until by chemical reactions they are thrown down. The least soluble are naturally the first to appear, the water becoming progressively more and more saline till it reacnes a condition like that of the mother-liquor of a salt-work. Gypsum begins to be thrown down from sea-water when 37 per cent. of water has been evaporated, but 93 per cent. of water must be driven off before chloride of sodium can begin to be deposited. Hence the concentration and evaporation of the water of a salt-lake having a composition like that of the sea would give rise first to a layer or sole of gypsum, followed by one of rock-salt. This has been found to be the normal order among the various saliferous formations in the earth's crust. But gypsum may be precipitated without rock-salt, either because the water was diluted before the point of saturation for rock-salt was reached, or because the salt, if deposited, has been subsequently dissolved and removed."* This theory would necessitate the belief that the deposits, now being considered,

[redacted]

the river Dove and afterwards with the river Derwent of Derbyshire. Both of these lastnamed rivers have their source in limestone regions, and it may be that the beds of gypsum have been originally carbonates and afterwards changed by the action of springs into sulphates. Again, the rivers may have had something to do with the deposition of the gypsum-beds. In the case of the Dove valley, it rather seems that the river had cut through the overlying strata and denuded the beds and so exposed them on the valley-side. It must be noted that the gypsum is here found only on the south side of the valley and considerably above the present river-level. The section (Fig. 2, Plate X.) affords some idea of the position of the deposit with reference to the river Dove.

Uses of Gypsum.—The massive form of gypsum, known as alabaster, is much used by sculptors, especially in the construction of fonts, reredos, pulpits and memorial tablets in churches. It is also used for pillars in, and for lining the walls of, large public buildings, such as the Holborn Restaurant, the Coliseum, and many large hotels, banks, etc., in London and elsewhere. It is only in a few places that the gypsum is found sufficiently "massive" to be suitable for use as alabaster-blocks, and hence these may be considered as somewhat of a "bye-product" in gypsum-mining, except in the Dove valley.

The bulk of the gypsum extracted from the mines is sent to plaster-mills, where it is manufactured into Italian plaster, plaster of Paris, Parian cement, Keens cement, floor-plaster, mineral, and various patent plasters or secret mixtures.

The uses to which these plasters are put are very varied. The finer varieties are largely used in the arts, and in various industries for mould-making and other purposes. The best and commoner varieties of plaster, Parian cement and Keens cement, are used for the internal lining and ornamentation of buildings, and a large quantity is absorbed in manufacturing blocks or slabs of plaster for use as fireproof partitions, etc.

Statistics.—Within recent years there has been a great increase in the quantity of plaster produced in this country. In 1881, only 79,498 tons were produced, divided between Derbyshire 12,928 tons, Nottinghamshire 49,604 tons, Staffordshire

7,456 tons, and Sussex 9,510 tons; while in 1905, Staffordshire produced 50,592 tons, the total for England being 255,508 tons (Table I.).

TABLE I. – OUTPUT OF GYPSUM IN ENGLAND.

Counties.	Quantity Obtained.			Total Values.
	From Mines.	From Quarries.	Totals.	
	1895.			
	Tons.	Tons.	Tons.	£
Cumberland	22,073	29,621	51,694	15,085
Derbyshire	8,884	—	8,884	4,442
Nottinghamshire	48,792	22,574	71,366	33,368
Somerset	—	4,800	4,800	795
Staffordshire	29,808	—	29,808	12,500
Sussex	7,416	—	7,416	3,731
Westmorland	1,440	2,484	3,924	1,914
Yorkshire	—	—	—	—
Totals	118,413	59,479	177,892	71,835
	1900.			
	Tons.	Tons.	Tons.	£
Cumberland	24,594	17,200	41,794	8,359
Derbyshire	10,289	—	10,289	4,630
Nottinghamshire	49,933	27,559	77,492	32,208
Somerset	—	5,110	5,110	1,265
Staffordshire	47,736	—	47,736	15,700
Sussex	17,768	—	17,768	5,730
Westmorland	2,400	5,449	7,849	1,750

[redacted]

Gypsum-deposits of the Dove Valley.—It has long been recognized, by those who have studied the subject, that it is to the presence of these deposits under and in the hills from which the breweries derive their water-supplies that the pre-eminence of the beers brewed in Burton-upon-Trent is due; and this fact, as well as the ancient history of the deposit already alluded to, gives a special interest to the study of the deposits of the Dove valley.

The deposit, so far as at present proved, lies near the village of Hanbury and just to the south of the road which leads from Tutbury castle to Sudbury. The three mines, which are now working, are situated close to this road (Fig. 1, Plate X.). Two of the mines are situated at Fauld (Fig. 6), and one at Draycott-in-the-Clay. The mine operated by Messrs. J. C. Staton & Company at Fauld has been worked by them or their predecessors for very considerably over 100 years. It was originally an open quarry, and there is still to be seen the old kiln where the gypsum was burnt, and the threshing-floor, where the burnt stone was beaten with flails into powder and in that condition it was sold as plaster. In those days, 60 to 80 years ago, the production of alabaster and plaster was so limited that it was customary, when a large building-operation was entered upon, for the owner or

FIG. 6.—ENTRANCE TO FAULD MINE.

builder to pay down a lump sum to the quarry-master, sending an agent to see that he obtained the quantity of alabaster or plaster contracted for, and that it was not sold elsewhere.

Messrs. J. C. Staton & Company had another quarry adjoining the old one, but both are now abandoned owing to the cost of removing the overburden, and the deposit is worked as a mine by means of a tunnel running into the hill-side.

The stone is dressed and sorted (Figs. 7 and 8) at the tunnel-entrance and then sent over a private railway into the valley (Fig. 9), over the river Dove to the North Staffordshire railway

The gypsum is found cropping out on the hill-side, and has been proved to be a continuous though irregular deposit, which runs back, how far has not yet been ascertained, into the hills. The gypsum is of the massive variety, crystals being very rarely met with. All classes of stone are mined, from large alabaster blocks, either pure white or veined or coloured, and the best white gypsum from which the highest grades of plaster are made, through the various grades, down to stone so mixed with marl as to be valueless. Anhydrite, or, as it is called locally, "hard stone," is met with in varying quantities.

Fig. 8.—Dressing-sheds at Fauld Mine.

It is difficult to account in any satisfactory way for the presence of this anhydrite in the gypsum. Mr. D. Burns states that in the Eden valley it is found about the middle of the seam, and apparently it is there of about the same thickness throughout. In the Dove-valley deposit, it is found, according to the writer's experience, sometimes in one part and sometimes in another part of the seam, although never immediately in contact with the roof or floor of the mine, and it comes in and goes out without any apparent reason. There seems to be no dividing line and no

clear cleavage between the gypsum and the anhydrite. The hard stone is often intimately mixed with the best gypsum-stone; it then has much the same appearance, and, at times, it is only by testing with the pick that the hard stone can be detected. Near the surface, anhydrite is rare, and it seems to increase with the thickness of cover. Where the seam is at its thickest, and at times it runs over 20 feet thick, a seam of anhydrite is often found above the usual height of the stone, with a further thickness of stone of the best quality above it. Fig. 3 (Plate X.) gives an idea of the occurrence of the hard stone: *a* shews the seam of

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is a problem for the chemist to discover whether the anhydrite could not be hydrated by some simple method and so made of commercial value.

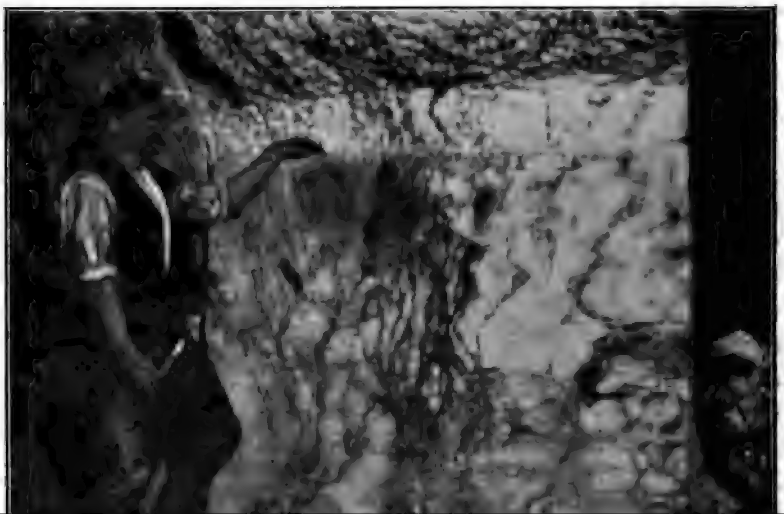
As the workings proceed further into the hill, the quantity of anhydrite seems to increase, and it then occurs more frequently near the middle of the seam. It still does not form a continuous seam, but will extend for 15 or 20 feet at one place and will then disappear, only to reappear at some distance further on. There is no apparent reason either for its coming in or going out. It does not seem to be affected by water, as it is found in some parts of the mine where considerable quantities of water are met with. The writer is unable to evolve any satisfactory theory to account for the presence of anhydrite in the gypsum-deposit, and all that occur to him appear to be inadequate, when examined in the light of experience.

FIG. 10.—MAN BORING A SHOT-HOLE IN FAULD MINE.

An interesting feature of these gypsum-deposits, but one which adds considerably to the cost of working, is the presence of "wash-holes" (Fig. 4, Plate X.). They are circular holes, varying in size, which run up through the stone, and often through the hard roof-marl, into the softer overlying marl. Some of these holes are large and circular in form, and appear to have

been formed by the "swirling" action of water. The cavities of wash-holes are usually empty. Other holes are found, consisting of long, narrow fissures filled with the soft earth which lies above the marl-roof. These fissures are found when approaching any surface-depression, and require to be timbered.

The roof of the deposit is composed of hard marl containing still harder blue marl "bullets." It stands very well when dry, but in wet places a layer varying from 18 inches to 3 feet in thickness soon "sags" and, where a road requires to be kept open, this must be either pulled down or timbered. Oak props,



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Methods of Working.—There is nothing special about the methods of getting out the gypsum stone for the mills. The system adopted is a kind of pillar-and-stall. There is, however, not the regularity in size of the stalls and pillars that is usual in coal-mines, as this depends so much on the varying conditions in different parts of the mine, how the roof stands and the quality of the rock. The great aim being to leave as little good stone as possible in the mine, the pillars are, so far as possible, left where the stone is inferior. They are generally left large enough to be cut through again when the working-places are finished. The

FIG. 12.—MEN SAWING AN ALABASTER-BLOCK IN FAULD MINE.

rock is soft, and easily bored with auger-drills (Fig. 10). This is done by hand, and so quickly that there seems no encouragement to go in for mechanically operated drilling-plant. Powder is used entirely for blasting.

The method of obtaining blocks of alabaster is more complicated, as it is of the utmost importance that they shall not be in any way shaken by blasting. Where good solid rock occurs, and it appears suitable for cutting into alabaster blocks, all blasting in the immediate neighbourhood is stopped (Fig. 11). The rock is first "topped": that is, the roof is undercut just above the good

stone and it is then blown down with lightly-charged shots, until the rock is cleared for about 4½ feet to 5 feet back, and about 2½ feet to 3 feet in height above the block, and this space is available for the workmen (Fig. 5, Plate X.). A gutter about 10 inches wide is then cut along the back of the block, for such a length as may be considered advisable, and others at each end, so that the block, generally 4½ feet wide and from 4 feet to 20 feet in length, is entirely separated from the rest of the rock, except at the bottom. The thickness of the block is then determined: usually it will be half the thickness of the rock, so as to obtain two blocks of equal size. A line is marked along the block at the height required, and auger-holes are bored through the block. Steel feathers and wedges are then inserted in the auger-holes, and the block of alabaster is forced from its bed. It is then turned over, examined, and any inferior stone dressed off. If too large, or if one end should prove to be inferior or shaken, the block is sawn (Fig. 12) into such lengths as may be desirable, and it is then ready to be loaded on to waggons and sent to the artist or manufacturer. It is unfortunate that every block does not turn out to be good alabaster, and a large percentage prove, after going to considerable expense, to be valueless.

Extent of Deposit.—It is difficult to estimate the probable extent of the deposit beneath the Hanbury hills, although the question is a most interesting one. There are at present no data to go upon as to how and where the deposit is cut off; but, from [redacted]

deposits were of Tertiary age, unlike those of Nottinghamshire, Staffordshire and Cumberland, which were Triassic, and those of Sussex, which were of Purbeck age. The alabaster-deposits at Volterra in Tuscany had also long been worked. He could not agree with the author that the method of deposition had not yet been properly elucidated: Sir Archibald Geikie's views appeared to be perfectly clear, and were supported by the fact that the formation could be seen in progress in the Dead Sea of Palestine, and in the Great Salt Lake of Utah. These views were further confirmed by Mr. Wynne's observations on the Salt Lakes of Persia. Gypsum was very largely used as a fertilizer, as well as in the manufacture of Portland cement, and a considerable amount was used in the " Burtonization " of beer. He regretted that more particulars were not given regarding the manufacture of plaster, for in this branch of industry there had been practically no technical progress; and the manufacture was now almost as it was in 1686, when described by Dr. Robert Plot, except that coal replaced wood and the steam-engine was sometimes used instead of horses for driving the mills. Scientific progress had hardly touched the technology of plaster. Manufacturers did not concern themselves about the temperature of burning, or about the degree of fineness of the material. These considerations had recently induced the International Association for Testing Materials to appoint a Committee to deal with gypsum, and to ascertain whether it would not be possible to draw up a scheme for the unification of the methods of testing that material.

Mr. G. A. Lewis (Derby) said that, in the various districts where gypsum existed in this country, the conditions of working, the thicknesses, and the qualities of the stone varied to a considerable extent. In the Eden valley, the seam attained a thickness of 30 feet, and it was partly quarried in open-works, and partly mined: the system depending upon the amount of cover. In Nottinghamshire, the deposit consisted of almost contiguous, roughly spherical masses of gypsum, with a thickness varying from 6 to 12 feet, somewhat flattened on the top. The method of working was to extract the masses of gypsum, and to leave the intervening strata as pillars to support the roof. The better qualities of stone were, however, found in two

thin seams overlying the main seam, and these two seams were won by ripping down the roof, where the thicker seam had been previously extracted. The mine at Mountfield, Sussex, was of greater interest to mining engineers, as it was the only gypsum-mine in this country worked on the longwall system; and it was, of course, the only mine where the conditions of the seam, the roof, the floor, etc., were sufficiently regular to make such a system possible. The question of anhydrite was a most interesting one, and he had met with the largest quantities in the thick seams of the Carlisle district. His experience had been that wherever there was a level roof on the top of the deposit at Carlisle, the anhydrite was nearly always found in considerable thickness in the middle of the deposit; they occasionally came across fissures in the rock, where the water had had access to the gypsum in years gone by, and, wherever these fissures were found, there was no anhydrite in the seam. He was consequently led to the conclusion that wherever water had free access, the anhydrite had been changed into true gypsum, and that the original deposit consisted wholly of anhydrite which, in the course of ages, had been converted into pure gypsum. He could not agree with Mr. Brough that the manufacture of gypsum was antediluvian. The progress made could not (it was true) be compared with that shewn in the development of the iron-and-steel industries, but the improvements were of a far-reaching character, and the method of treatment and [redacted]

substantial progress made in Staffordshire in the measures adopted for treating the gypsum and preparing it for market. He (Mr. Wain), through the kindness of Mr. Trafford Wynne, had been able to inspect the up-to-date machinery in use at the Tutbury works, and was impressed by the extent and efficiency of that plant. The arrangements were conducive to economy, and, at the same time, it was interesting to note that in the preparation of some of the finer qualities of plaster very great care had to be taken, and some of the finest kinds were specially hand-picked and scrubbed with a brush before grinding. Large quantities of plaster were used in the manufacture of pottery, for mould-making, etc., and it was satisfactory to know that the local supplies were not likely to be exhausted in the immediate future.

Mr. J. T. Stobbs said that the authority quoted as to the origin of gypsum was Sir Archibald Geikie, but a later authority was Prof. Van t'Hoff, who had proved experimentally that the salts were separated out in the order of crystallization. Mr. Wynne stated that the principal deposits of gypsum were found in valleys, such as the Eden, the Dove, etc., and the water flowed from the Carboniferous Limestone region; in other words, the writer was trying to connect the deposition of gypsum with the accidental occurrence of rivers. He suggested that the occurrence of deposits of gypsum in these localities was not sufficiently explained by the fact that it was only in these districts that deposits of Trias were known to occur at the surface; for the Trias, even where overlain by later formations, would also be found to contain deposits of gypsum.

Mr. Charles Chandley (Nottingham) said that he had put down some bore-holes in one of the salt-lakes of Australia, some years ago, and the water contained, amongst other salts, a saturated solution of sulphate of lime. The strata passed through were curiously analogous to the beds containing gypsum in Nottinghamshire.

Mr. David Burns (Carlisle) wrote that Mr. T. Trafford Wynne's paper failed to throw light on the origin of gypsum. The author stated that gypsum occurred in the marls overlying the salt-deposits, and then quoted Sir Archibald Geikie to shew

that gypsum below and rock-salt above was "the normal order among the saliferous formations in the earth's crust."* Unfortunately, the geologists of the present day were too much like the ethnologist who claimed to be throwing light on the origin of the human race by pointing out the house that a friend lived in before he occupied his present dwelling. The study of the deposition of minerals on the bottom of salt-lakes was most interesting, but as the gypsum that they contained had been dissolved from gypseous rocks elsewhere, the explanation of the origin of gypsum was as remote as before the investigation began. The quotation from Sir Archibald Geikie might, however, afford some explanation of the source of the gypsum that the author had seen surrounding a great salt-area in Northern Persia. Given a sea, irregularly fed by mineral waters, with no outlet, and under a tropical sun, it was conceivable that, at the beginning of each dry season, a maximum of gypsum would be deposited round the shallow margin, and that later salt would be deposited in the central area. Mr. Wynne gave the general composition of gypsum and anhydrite, but if he could give the exact analyses of these two rocks as they occur in the Dove valley, he would add much to the value of the discussion. He (Mr. Burns) had been told of analyses shewing considerable silica in the anhydrite, but he had never been able to meet with one. Gypsum had generally been found in valleys, because it occurred among soft and perishable marls, but there was no reason why the same beds of gypsum should not extend under hills, where the marls extend, [redacted]

meaning. There was probably, however, on the average, more anhydrite in the Eden valley than in the Dove valley, for reasons to be given. Mr. Wynne stated that the best gypsum was often found close to the hard stone, but this was very exceptional in the North of England, the usual rule being that the best gypsum occurred where there was least "cobble." Anhydrite followed the same laws in the Dove and Eden valleys in respect to the cover: that was, the greater cover afforded the greater proportion of anhydrite. He (Mr. Burns) had given sections to shew the connection of water with the absence of anhydrite, and it was unfortunate that Mr. Wynne had not given sections to prove the contrary. The distribution of water in the mines now was scarcely relevant evidence, as the course of the water underground might be very different since the mines began to be worked. If Mr. Wynne had found anhydrite adjacent to a wash-hole, like that shewn in Fig. 4 (Plate X.) it would be most important evidence. Wash-holes in themselves did not present any difficulty, and were similar to those found in limestone. The round and smooth walls of these holes were due to the uniform solubility of the gypsum, and not to any swirling action of the water. When of the form shewn in Fig. 4 they must have been continuously, or, during the wet season, quite filled with water. The balls in the roof were very interesting, and should they prove to be the representative of the "green bed" in the Eden valley, they would be a further proof of the identity of conditions in the two valleys when the gypseous rocks were laid down. He (Mr. Burns) would be obliged if Mr. Wynne would state whether he ever worked the gypsum to its limit, and found it abutting against marls of its own age. He had always found that it was cut off by boulder-clay or other superficial deposits. In Fig. 3 (Plate X.) Mr. Wynne showed an inverted dome at the bottom of the bed, under the dome at the top. If he had found in his experience in the Dove valley, that this was a usual occurrence, he (Mr. Burns) would be surprised and puzzled: he might safely state that there was no approach to such irregularities in the case of the deposit in the Eden valley. If the top of the gypsum in Fig. 3 (Plate X.) was correctly drawn, it shewed that the marls rested unconformably upon it, as he found that they did in the Eden valley: that was, the top of the gypsum had been a land surface subject to subaerial denudation, before

the deposition of the marls. Assuming that the maximum of anhydrite was found in the centre of the depth of the original bed as laid down, which was extremely probable, he arrived, with the help of Fig. 3, at the following comparisons:—In the Eden valley the original bed had been 29 to, say, 23 feet thick, while the Dove bed had been 26 feet thick. The denudation in the Eden valley had been more irregular, leaving the rock in places nearly of its original thickness, but sweeping it entirely away from large tracts. The denudation in the Dove valley had been more uniform, leaving the bed continuous for several miles (Fig. 1 Plate X.), but it had planed down the whole bed till the process was arrested by the harder anhydrite (Fig. 3, Plate X.). Consequently, the hard rock was now found at the top of the remaining bed, and in the centre of a dome. Seeing that the two deposits had been of almost identical thickness when formed, one would naturally expect the same proportion of anhydrite in the two valleys. There could be little doubt that there was a less proportion in the Dove area now. This had probably arisen from the difference in the denudation, placing the anhydrite at the upper surface of the deposit in the Dove valley, where it had been altered by moisture into the excellent rock, *d* (Fig. 3), but keeping it in the centre of the deposit in the Eden valley, where, unhappily, it had been better preserved. That, to his mind, was about the most conclusive evidence hitherto produced that anhydrite had been gradually altered into gypsum. If the inverted dome shown at the bottom of the gypsum (Fig. 3)

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the conversion of anhydrite into gypsum, more strongly and confidently. He pointed out that the deposits of gypsum lay along a line: could that line have been a continuous one in Triassic times from Carlisle to Tutbury? The close similarity of the two beds would almost warrant such a belief.

Mr. T. TRAFFORD WYNNE, replying to the discussion, said that he was neither an experienced geologist, nor yet a manufacturer of plaster, but simply a mining engineer who had had a few years' experience in this particular branch of mining. Mr. Brough seemed to have somewhat misunderstood the terms used in the trade: gypsum that had been baked or calcined and afterwards ground to powder was known as "Italian plaster," and plaster of Paris was gypsum, broken and ground to any desired degree of fineness, and then boiled on open hearths. Within the last few years, great improvements had been made in the mode of boiling: circular hearths on which the plaster was constantly kept stirred by mechanical means, having been substituted for "slip-hearths" and hand-labour. The stuff described by Dr. Plot, which Mr. Brough appeared to think was substantially the same as what was now sold as plaster of Paris, more resembled "floor-plaster," which was now but little used. The International Association for Testing Materials, mentioned by Mr. Brough, appeared to have fallen into the common error of expressing an opinion before enquiring as to the facts. It would, he ventured to think, have been better if they had made at least some enquiry into the subject before they began to criticize.

Mr. Burns' explanation of the stone lying above the anhydrite being the best stone was very interesting, and appeared to be confirmed by the fact that there was no well-defined cleavage between good gypsum-stone and anhydrite, in fact, at times, they appeared to be homogeneous. The depressions in the floor of the deposit were numerous, the thickness of the stone was very variable, sometimes it thickened upward, and sometimes downward, but most often as shown in Fig. 3 (Plate X.). The writer had not, at present, found the limit of the gypsum-deposit, except at its outcrop, and so far as the deposit which he was working was concerned, he confessed that he had no desire to do so. He had within the last month found anhydrite,

not in close contact with a wash-hole, but within 9 feet of one. It was found in a "top" as shown in Fig. 3, and about 6 feet from the edge of the high top the workmen broke into a "wash-hole."

He wished also to make it clear that he did not put forward any geological theories of his own, but he merely stated facts as they appeared to him, and left it to his readers to form their own conclusions.

The CHAIRMAN (Sir Lees Knowles, Bart.) said that the value of the paper principally depended on the personal observations and the special knowledge of the writer with regard to the Dove-valley deposits. He proposed a vote of thanks to Mr. Wynne for his paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

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NOTES ON CAULDON LOW AND THE MANIFOLD VALLEY, NORTH STAFFORDSHIRE.

By E. B. WAIN and J. T. STOBBS.

After skirting the eastern outcrop of the Pottery coal-field, from Milton station to Stockton Brook, the railway passes over rocks of Lower Coal-measure and Millstone Grit age, which now and again are unconformably overlain by Bunter Conglomerates or Keuper Sandstone. At Leekbrook, red Triassic

FIG. 1.—BLAST DISLODGING 30,000 TONS OF CARBONIFEROUS LIMESTONE, *a* TO *b*, IN CAULDON LOW QUARRIES.

sandstones, showing current-bedding, rest on the black shales of the Pendleside series, and in No. 2 cutting of the Leek light railway specimens of *Sphenopteris lanceolata*, Feistmantel (*non* Guthier) have been collected from a plant-bed: *Posidoniella lævis* and *Pterinopecten papyraceus* also occur there.

Pendleside shales may be observed in the cuttings, almost all the way from Leekbrook to Cauldon station, and they are much crushed and contorted—perhaps the North Staffordshire phrase "all of a ruck" most aptly describes their occurrence. They

contain a fair amount of carbonaceous matter, and near Waterhouses a spoil-heap, formed of the débris from one of the railway-cuttings, has fired spontaneously. In the cutting through these shales, nearest Cauldon station, layers of large calcareous bullions are found: they are very fossiliferous and have yielded:— *Glyphioceras bilingue (?)*, *Glyphioceras reticulatum*, *Orthoceras* sp. and *Posidoniella lævis*. In the shales themselves, *Posidoniella lævis* is abundant, and a single fragment of *Dicrenodus dentatus* has been obtained.

At Cauldon Low, a large quarry (Fig. 1) of Carboniferous Limestone of very pure quality is worked by the North Staffordshire Railway Company: it is sent as a fluxing agent for the blast-furnaces of North and South Staffordshire, and is largely used in the chemical works of the Northwich district. The following analyses show the composition of this limestone:—

	Blue Limestone.	White Limestone.
Lime *	55·40	55·35
Magnesia	0·47	0·47
Alumina and oxide of iron ...	trace	trace
Silica	0·45	0·35
Phosphorus	trace	trace
Sulphur	trace	trace
Carbonic acid, etc.	43·68	43·83
	100·00	100·00

* This equals pure carbonate of lime, 98 91 and 98·84 per cent.

The top of the hill is about 1,200 feet above sea-level, and the area quarried is about 300 acres: the height of the face of the [redacted]

The beds of limestone all belong to the *Dibunophyllum*-zone, and in this locality fossils are not very abundant. Large gastropods are found (*Naticopsis* sp., *Bellerophon* sp., being the commonest and generally occurring as casts, known as "turns" to the quarrymen), and that rare brachiopod *Productus humerosus* is occasionally obtained, as well as *Chonetes papilionacea*, *Orthotetes crenistria*, etc. The probably-faulted junction of the Pendleside Series and the Carboniferous Limestone may be noted beside the schools at Waterhouses. Near this village the highest beds of the Carboniferous Limestone are exposed: they are characterized by a "rolled-beach" bed of *Producti* and the presence of Cyathaxonoid corals.

From Waterhouses to Beeston Tor, the water of the river Hamps, in dry weather, is all carried in underground channels; and at the latter place, which forms the junction of the rivers Manifold and Hamps, the same remarkable disappearance of the water from the bottom of the Manifold valley may be noticed. The picturesque gorges and sinuosities of this valley, produced by a combination of geological causes, are much admired. The precipitous scarps reveal repeated and rapid folding of the beds, the solubility of which under weathering action is very unequal, and thus a variety and boldness of feature has been produced which constitutes the singular charm of Carboniferous Limestone country. The higher beds in the locality are irregularly cherty.

Thor's cave, near Wetton, has been produced in the way just mentioned by the action of a stream. In the cave-earth forming its floor, the remains of extinct mammalia and human implements were discovered.

The limestone-quarries of Wetton and the surrounding district were the collecting-ground of Samuel Carrington, who supplied many specimens to Thomas Davidson in the preparation of his great monograph on British fossil Brachiopoda. The Nottingham Museum contains an excellent collection of Carboniferous Limestone fossils from this neighbourhood—probably part of the result of Carrington's labours.

The Ecton copper-mine, near the terminus of the railway, was at one period of great importance. In 1686, Dr. R. Plot recorded in his *Natural History of Staffordshire* that it had been worked for several years, but was stopped before he visited the

place, because of the competition of Swedish ores. He stated that the veins were from 24 to 150 feet deep, and that the ore was smelted at Ellastone.* John Mawe, in 1802, gave an account (with a figured section of Ecton Hill) of the mine in his *Mineralogy of Derbyshire.* He recorded that, in addition to copper-pyrites, galena, fluor, calcite and barytes were found, "the famous vein being what the Germans call a *stock-work.*"† At that time the mine was one of the deepest in Europe, going down to 1,320 feet: it was extremely productive, and employed more than 1,000 persons. "The rich ore was in amazing large heaps, being in some places 70 yards broad and in others not above ten."‡ It was taken to Cheadle, Staffordshire, for smelting, that being probably the nearest locality where good coal was being worked. The mine was finally closed in 1891, again due to the competition of cheaper imported ores. There are extensive copper-works at Froghall and Oakamoor, which no doubt formerly worked up the ore produced at Ecton and smelted at Cheadle.

The scenery throughout the Manifold valley may be classed amongst the most beautiful in this country; but until recently it has been inaccessible, except to pedestrians. The opening, last year, of the light railway from Waterhouses to Hulme End has now brought it within easy reach of the Potteries and the Manchester district.

In conclusion, the writers desire to express their indebtedness to Mr. G. J. Crosbie Dawson, F.G.S., chief engineer to the [redacted]

seen the forge in which the first drill was made, and that the first shot fired was in the Ecton mine. The drill was made by one of the German miners brought over in 1636 by Prince Rupert for working the mine. Marks of these drills could still be seen in the so-called Dutchmen's adit, the name of which indicated that it was driven by German miners.

The CHAIRMAN (Sir Lees Knowles, Bart.) moved a vote of thanks to Messrs. J. T. Stobbs and E. B. Wain for their interesting paper.

Mr. P. KIRKUP seconded the resolution, which was cordially approved.

DISCUSSION OF MR. SAM MAVOR'S PAPER ON THE "PRACTICAL PROBLEMS OF MACHINE-MINING."*

Mr. C. H. MERIVALE (Leeds) said that the use of coal-cutters on sledges increased the length cut by 33 per cent., but, in one seam, their use had been somewhat restricted. The section comprised 17 inches of top coal, 8 to 24 inches of stone, and 6 inches of bottom coal. The cut could only be made in the soft stone, below the top coal. This stone varied in thickness, even on a face only 500 feet long, so that the height of the cut, above the floor-level, had to be continually altered. This could easily be done by packing up the sleepers, where rails were used; they had tried to raise the sledge-machine, by sliding flat boards below it. Possibly Mr. Mavor might suggest another method, by which the position of the cut could be altered, while the machine was running, through a vertical distance of 18 inches.

Mr. SAM MAVOR said that the altering of the vertical position of the cut was a matter of no difficulty, within the limits of about 9 inches, and the Pickquick cutter was provided with adjusting screws for altering the position of the cut. A range of 18 inches might be possible by a modification of the same arrangement, but to raise the machine 18 inches by such means would, he feared, render it rather unstable; and it would be liable to vibrate unless a very special base was used.

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* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 378.

DISCUSSION OF DR. J. A. ROELOFSEN'S PAPER ON "BYE-PRODUCT COKE AND HUESSENER BYE-PRODUCT COKE-OVENS."*

Mr. B. Dodd (Bearpark Collieries) wrote that bye-product coke-ovens were successfully introduced into the county of Durham in 1881 and 1882 by Messrs. Pease and Partners, Limited, at Crook, and by the Bearpark Coal and Coke Company, Limited, at Bearpark; and these ovens of the Simon-Carvès type are still working successfully, and give as good results as any other retort-ovens: the Huessener and Solvay ovens being modifications of this type. The chief difference in retort-ovens is between vertical and horizontal flues; but, so far as uniform heating is concerned, there appears to be little difference. In vertical-flued ovens, the flues are difficult to see into, the leaks are not so easily seen as with horizontal flues, and, consequently, they get a credit for tightness which they do not possess. It should, however, always be remembered that the oven is only a part of a bye-product plant; and, perhaps, the least important part.

The quantity of bye-products obtained and the ease of working depends upon the power of the plant for condensing and dealing with the gases given off. The speed of carbonization and the regularity of heating depends upon the quality and steadiness of the condensation, and upon the regularity with which the gases are returned to the ovens to be burnt in the flues; and, therefore, the plant should be considered as a whole.

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received and coked, was only 67·69 per cent. of coke containing 3·97 per cent. of moisture or 63·72 per cent. of the coal received. Together with the coal, a considerable amount of hydrogen in the form of water was introduced into the ovens, washed coal being used containing 10·6 per cent. of water; and, when this was taken into consideration, the yields did not appear any better than that of older plants.

It would add considerably to the value of the paper if the results of the hand-charged and compressor-loaded batteries were compared. Judging from the time that the Port Clarence plant had been working, the advantages of one method over the other did not appear to be sufficiently marked to have brought about the introduction of a uniform system throughout; or possibly hand-loading possessed some especial advantages.

It was satisfactory to learn from Dr. Roelofsen that retort-coke gave good results in the furnace, as this confirmed what had been stated by the makers of retort-coke for the past 16 years: namely, that retort-coke, if properly used in up-to-date furnaces, would give satisfactory and economical results.

It was also satisfactory to know that the prejudice which had existed against retort-coke was being overcome. When this class of coke was introduced into the county of Durham 15 years ago, the makers, not being blast-furnace owners, had to sell it in the open market; and blast-furnace owners, from prejudice and in order to buy at the lowest prices, looked upon it with apparent disfavour. But, its advantages being now realized, it was largely used, and blast-furnace owners were purchasing coal and erecting ovens to make this class of coke.

In many districts, thinner seams, which were more difficult to clean, and seams containing shale-bands would be worked; and it was almost certain that retort-ovens would be improved and adapted to work with mixed shale and coal for the production of hydrocarbons and other chemicals, at the collieries: the resulting cinders being looked upon as a bye-product. In this way, much of the matter now wasted in spoil-heaps would be utilized with profit to colliery-owners, and a great national saving would be effected, while the pure coal would be sold for coke-manufacture.

Mr. J. Kenneth Guthrie (Newcastle-upon-Tyne) wrote that he could not agree with the conclusions of Dr. Roelofsen, as to

the superiority of horizontal flues; and he was strongly of opinion that the vertical type of flue was much superior, since the distribution of the heat was the most perfect possible and the direction of the flame throughout was the natural one (that was, upwards), by means of its own buoyancy and not on account of chimney-draught. The draught, required for combustion, was reduced to a minimum, compared with that of the horizontal flue, where the gases had to travel long distances. In the vertical type of flue there was an equalization of pressure between the oven and the flues, so that leakages of gas from the inside of the ovens to the heating-flues, or *vice-versa*, were practically avoided. This equilibrium of pressure was of the utmost importance, as being the only efficient means of preventing the harmful passage of chamber and flue-gases through the joints of the separating flue, and the consequent loss of bye-products. The resistance of the wall was enhanced by the vertical-flue system, as the heating flues ran perpendicularly along all that portion of the oven-wall against which the coal could exert any pressure, and the divisions between the flues formed vertical strengthening ribs. This was especially advantageous when coals of only slightly shrinking and even expanding nature were coked, such as occurred in the case of all coals low in volatile matter. In horizontal flues, built of hollow tiles, with expanding coals, the weaker flue-walls were apt to be crushed by the pressure exerted by the coal. The vertical-flue system had the further advantage that it could better withstand the compression-loads due to the

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of the bye-product oven dated from 1896, when Mr. K. Hilgenstock introduced the heating of the vertical flues of the Otto oven, by Bunsen burners inserted in accessible passages placed underneath the oven-block; at the same time dispensing with the preheating of the air by regenerators. The success of the new departure was proved by the greatly increased number of ovens built after this design, and the efforts of others to build after the same plan, so far as patent rights would permit. The horizontal flue received very little support in Germany, the home of the retort-oven; and it might be added that the first builders of that system had abandoned it, and had become converts to the rival system.

The temperature-curve would have been more interesting if, instead of showing only one line, it gave curves taken at different points of the oven. These would differ greatly, as the carbonization commencing from the outside, the moisture was here driven off quickly; and the time extending until the inside was reached, where the carbonization was completed, and where the moisture was last driven off.

Dr. J. A. Roelofsen said that he quite agreed with Mr. Dodd as to the ease of inspecting ovens with horizontal flues, as compared with vertical flues. It was also of the greatest importance that the bye-product plant should be constructed in such a way that the gases evolved were readily removed from the hot ovens, were thoroughly cleansed and deprived of their bye-products, and then returned in a regular and uniform flow to the oven-burners. With large apparatus, especially with large exhausters going at a slow speed, this was readily attained without the use of gas-holders. The latter were only necessary where surplus gas was used for consumption in gas-engines. He had given the yield of tar, sulphate of ammonia and benzole per ton of coke made, and also the percentage-yield of coke and breeze. It was, therefore, a matter of easy calculation to find out the yield per ton of coal charged into the oven. The figures quoted by Mr. Dodd as the actual working results of 52 weeks were evidently taken from a paper on Huessener coke-ovens read in 1904 by the late Mr. C. Lowthian Bell.* The yield of 67·69 per

* "The Manufacture of Coke in the Hüssener Oven at the Clarence Ironworks, and its Value in the Blast-furnace," by Mr. C. Lowthian Bell, *The Journal of the Iron and Steel Institute*, 1904, vol. lxv., page 188.

cent. was calculated on the coal as it was received from the collieries and before it was washed, the yield of coke and breeze as obtained from the coal actually charged into the ovens was 74·45 per cent., and the difference between these figures represented the loss in the washery. The consumption of raw coal at the old battery of 60 ovens at Clarence in 1903 was 105,000 tons; and since the publication of Mr. Bell's paper a new battery of 60 Huessener ovens had been erected, which were somewhat higher, and carbonized between 15 and 20 per cent. more coal than the old ovens in the same time. Coal charged in the compressed state, by means of a charging machine, gave on the whole a firmer coke than that charged by hand. In the case of coal which ordinarily did not give a very hard coke, the improvement was very marked and of great value; but, with coal such as that now being used at Clarence, which gave even with ordinary hand-charging a very hard and solid blast-furnace coke, the advantages of using a compressing machine were not so evident, and before adopting the compression of the coal at their old ovens, as well as at the new ones, they wished to have more information and a more extensive experience.

He thought that Mr. Guthrie underestimated the value of division-walls between the ovens, for not only did they strengthen the whole structure, but they separated adjoining ovens, with the result that most repairs could be effected without laying off the adjoining ovens. Where there was no such division-wall, one row of burners heated two adjoining oven-walls, and it was [redacted]

course, "hollow tiles" must never be used in coke-oven construction, and, so far as he was aware, they were not used, at present, in any of the various systems of coke-ovens. If Mr. Guthrie would carefully read the description of the Huessener ovens in his paper he would see that there were no "hollow tiles." Although the division-walls naturally added to the length of the whole structure, and perhaps slightly to the initial cost of the plant, at the same time they added very largely to the life of the plant and considerably reduced the amount of necessary repairs. Finally, he would like to point out that the first builder of bye-product coke-ovens, in the modern sense of the word, in Germany was the late Mr. Alfred Huessener; and that the Huessener oven still retained its principal feature, namely, horizontal flues, and there was no likelihood of any change in the direction of the vertical system.

DISCUSSION OF MR. T. ADAMSON'S PAPER ON "GOAF-BLASTS IN MINES IN THE GIRIDIH COAL-FIELD, BENGAL, INDIA."*

Mr. W. H. Pickering (Chief Inspector of Mines in India) has written the following remarks respecting "A Serious Danger in Bengal Coal-mining":—

The roof over the coal-seams in Bengal is, for the most part, very strong sandstone, free from joints and smooth partings, and it requires little timbering. In these conditions, the falls of small pieces of stone from the roof, which cause so many deaths in most coal-mines, are comparatively rare; but, unless proper mining methods are adopted, the remarkably sound roof becomes a serious danger, instead of being a factor of safety. Some managers and owners, presuming on the naturally safe conditions, drive the galleries so wide, and leave such small pillars that the roof falls over a large area, and crushes the small supporting pillars. This always results in a serious waste of coal, and frequently there is a grave danger of a loss of life on a very large scale. This danger, in some cases, will become even more serious in the future, when larger areas are mined, if the present methods are persisted in. Lives are not only endangered by the direct fall, but, when the roof falls over a large area, an air-blast is produced, and the air is forced through the galleries with such a velocity that it has the effect of an explosion. Two lives were lost from this cause . . . . . but a much more serious disaster was probably averted by the fortuitous visit of Mr. Grundy, the Inspector for No. 1 Circle, to Mouthdih mine, Sitarampur. When inspecting the colliery, Mr. Grundy came to the conclusion that the workings would soon collapse, and when I made an inspection with him

* *Trans. Inst. M.E.*, 1905, vol. xxix., page 425; and vol. xxxi., page 494.

a few days afterwards the indications were more pronounced, and it was evident that the roof in one part might fall at any moment, and extend over a large portion of the mine, for some of the galleries were 20 feet wide, the pillars irregular, and many less than 12 feet square, and the seam was 18 feet thick. The owners appeared to be sceptical, but listened to reason, and stopped the working of the mine. This course was justified by events, for only two days afterwards, and without further warning, the roof fell over an area of 5,000 square yards, and broke through to the surface. The air-blast was so violent that the mine was wrecked, and the earth-tremors caused by the blast and the fall were felt ¼ mile from the mine. The mine became waterlogged and it has not yet been possible to inspect it underground. The blast, however, had rushed up the shafts and inclines, and gave striking evidence of its violence on the surface. At one shaft, the blast lifted the headgear bodily, leaving only three uprights standing, and the pit-trolley, winding-pulleys, broken pieces of the headgear, etc., were blown some distance from the pit-top. At another shaft, the top of the headgear with the winding-pulleys was blown off, the pit-trolley was broken in pieces, and large pieces of timber were blown 50 feet away. Large stones were hurled up the inclines. It was most fortunate that the pit's company had been withdrawn, for no one could have been in the mine at the time of the collapse and escaped alive. At this mine, the pillars were being thinned without regard to systematic working, but in any case it would have been impossible to extract the pillars in safety owing to their smallness and irregularity, and the excessively wide galleries. Another collapse of workings happened at Deshergarh, where an area of 32,000 square yards of surface subsided with buildings and a main road, and it was providential that only one life was lost. In this case, the mischief had been done underground 20 years ago.

If the workings are properly designed, the pillars may be safely extracted, and, though the air-blasts will be a danger, ample warning of the fall will be given, precautions can be taken, and the roof will only break down over the area from which the coal is extracted, and will not crush over the pillars. Systematic pillar-working is in progress at several mines,

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as *chowkidars* or small tell-tale pillars. Thus, 98 per cent. of the coal had been won, and only 2 per cent. lost. This is ideal mining, but the extraction of such a percentage would not be possible over the whole area of the mine.* . . . . The regularity of the Kurhurbaree workings, compared with the irregularity of the other excavations, is most striking.†

Mr. T. ADAMSON wrote that goaf-blasts were not confined to Bengal coal-mines, as had been fully demonstrated in the discussion of his paper. The remarks made by Mr. Pickering showed that, when a mine was properly worked by forming pillars of sufficient size, the leaving of tell-tales (*chowkidars*) in the goaves, the systematic sounding of the roof‡ and listening for roof-movements several times during the shift by the mine-officials, as practised in the Joktiabad and other Giridih mines,§ ample time was given, between the first indication of weight on the *chowkidars* and the collapse of the roof, to remove all the workmen to a place of safety. On the other hand, when a mine was worked on a system (or want of a system) like that of Kasunda, a positive danger existed.

Akin to goaf-blasts was the action of creep, which generally produced wind-blasts. This ocurred where a large area was cut up into small pillars, and when an attempt was made to remove them, the roof settled on the pillars and crushed them out. A case of this kind happened at the Warora colliery, Central Provinces, India, in the early part of 1906. The pillars were being worked back, when suddenly, during one night, a large goaf-fall took place, which caused a serious subsidence of the surface and let down the main line of the Great Indian Peninsular Railway, under construction. Luckily the fall took place during the night, when there was no one in the mine. Had the fall taken place during the day, when 700 men were at work, the result might have been serious. The pillars were crushed out nearly back to the shaft, and the mine was, in consequence, abandoned.

The writer agreed with Dr. Robertson ‖ that the possible effects of goaf-blasts deserved further investigation and discussion.

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* *Trans. Inst. M. E.*, 1905, vol. xxix., Plate XIV., page 430.

† *Report of the Chief-inspector of Mines in India, for the Year ending 31st December, 1905*, by Mr. W. H. Pickering, 1906, page 10.

‡ *Trans. Inst. M. E.*, 1903, vol. xxv., pages 10-13.

§ *Ibid.*, 1906, vol. xxxi., page 500. ‖ *Ibid.*, page 499.

Mr. W. G. Phillips proposed a vote of thanks to the President and Council of the North Staffordshire Institute of Mining and Mechanical Engineers for making the arrangements for this successful meeting; and to the owners of works, etc., to be visited by the members.

Mr. J. H. Merivale seconded the resolution, which was cordially approved.

Mr. J. Nevin moved a vote of thanks to Sir Lees Knowles, Bart., for his services in the chair.

Mr. A. Sopwith seconded the resolution, which was cordially approved.

SHELTON IRON, STEEL AND COAL COMPANY, LIMITED.

Deep Pits.

The Deep Pits work the lower seams of the North Staffordshire coal-field. Two shafts, the upcast and downcast, are used for winding, each 17 feet in inside diameter.

At the east and downcast shaft, the winding-engine, with two cylinders, 40 inches in diameter and 7 feet stroke, is fitted with slide-valves and Melling variable cut-off gear. The parallel drum is 24 feet in diameter, and the locked-coil winding ropes are 5¼ inches in circumference.

At the west and upcast shaft, the winding-engine, with two cylinders 32 inches in diameter and 6 feet stroke, is fitted with Cornish valves and Markham automatic trip-gear. The parallel drum is 20 feet in diameter. The locked-coil winding ropes are 4¾ inches in circumference.

The east shaft is 2,661 feet deep, and winding takes place from a depth of 2,190 feet. The west shaft is 2,595 feet deep, and winding takes place from a depth of 2,550 feet. It is intended, however, upon the further development of the seams, to wind the output from the 2,550 feet level at the east shaft, and the output from the 2,190 feet level at the west shaft. The pit-head frames, built of steel lattice-girders, are 72 feet high to the centre of the pulleys, 18 feet in diameter. From the frames are suspended ten locked-coil conductors in the east shaft, and eight conductors in the west shaft, each 4½ inches in circumference. From 6 to 8 tons of cast-iron weights are attached to each conductor, so as to produce sufficient tension.

Ventilation is produced by a Walker fan driven by a compound engine. The high-pressure cylinder, 22 inches in diameter, is fitted with Corliss valves, and the low-pressure cylinder, 40 inches in diameter, is fitted with Meyer cut-off gear. The fan, 26 feet in diameter, is driven by eighteen ropes, 1¾ inches in diameter. A Chandler fan, 12 feet in diameter, driven direct by a compound single-acting Chandler engine, is provided as a stand-bye.

Steam is produced from two batteries of Lancashire boilers.

At the east pit, there are seven boilers, 30 feet long and 8 feet in diameter, and one 30 feet long and 9 feet in diameter; and at the west pit, two boilers 30 feet long and 9 feet in diameter. The pressure of steam is 150 pounds per square inch.

The continuous-current electric plant consists of three Mather-and-Platt combined generating sets, each of 200 horsepower, at 500 volts.

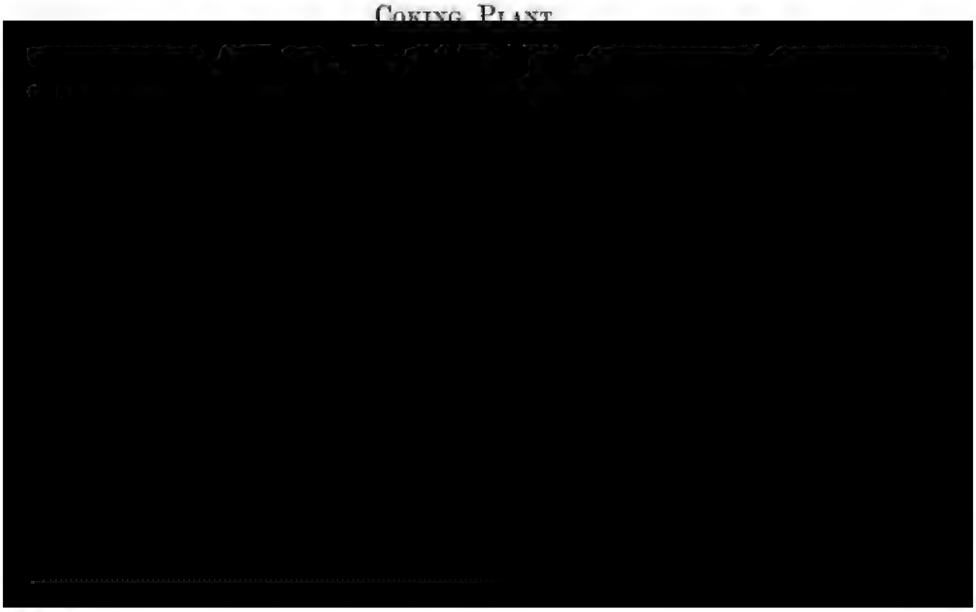
The seams lie at an angle of 15 degrees, and horizontal tunnels from the winding levels at each shaft cut the following workable seams:—Moss, Yard, Ten-feet, Bowling Alley, Holly Lane, Hardmine, Banbury and Cockshead.

The underground electric haulage comprizes one endless-rope set of 135 horsepower; one endless-rope set of 60 horsepower; two main-and-tail-rope sets of 50 horsepower; one endless-rope set of 36 horsepower; one direct-dip haulage of 50 horsepower; and one direct-dip haulage of 20 horsepower.

Pumping is effected by one three-throw pumping set of 30 horsepower, working against a head of 1,600 feet; and one three-throw set of 30 horsepower, pumping from a depth of 640 feet to the surface.

The screening-plant comprizes five mechanically-driven tipplers, delivering coal to one burgy shoot and four shaking-screens. There are four coal-picking belts, each 5 feet wide and 60 feet long; and the cobble and slack belts are also 5 feet wide.

Coking Plant



Electric Generating Station.

Two Koerting two-cycle double-acting gas-engines of 350 brake-horsepower are direct-coupled to dynamos. The surplus gas from the coke-ovens is used for driving these engines. There is a stand-bye high-speed steam-set and dynamo, of 200 horsepower.

The water-supply for the entire plant is pumped by two electrically-driven turbine-pumps.

Etruria Iron-and-steel Works.

There are four blast-furnaces, 70 feet high; and two blast-furnaces, of older type, 55 feet high. There are eleven hot-blast Cowper stoves, 20 feet in diameter and 60 feet high; and one stove, in course of erection, is 22 feet in diameter and 70 feet high. There are three beam-type blowing-engines and one vertical blowing-engine. Basic pig-iron is produced for steel-manufacture, together with forge, foundry pig-iron and special cylinder-iron.

There are eight Siemens basic-steel open-hearth furnaces, with nineteen Dawson-type gas-producers: five furnaces being of 22 tons capacity, two of 30 tons, and one of 40 tons. The largest furnace has regenerators at the back of the furnace and under the charging platform, and the building is prepared for the installation of an electrical overhead crane, with a view to using molten metal direct from the blast-furnaces.

The whole of the steel is rolled down in the cogging-mill, adjacent to the steel-melting shop, and either transferred direct without re-heating to the finishing mill, with rolls 32 inches in diameter; or, if rolled into slabs and billets, these are sheared to the lengths required and loaded into wagons for the small mills at the Shelton works. The cogging-mill is served by six coal-fired vertical ingot-heating furnaces, and the ingots are charged and transferred to the cogging-mill by two steam travelling-cranes. The cogging-mill, with rolls 38 inches in diameter, is driven by a horizontal engine, with two cylinders 42 inches in diameter and 5 feet stroke, geared 2 to 1 to the mill-train. The powerful steam-driven vertical shears are capable of cutting hot blooms, 10 inches square.

The girder rolling-mill, with rolls 32 inches in diameter, comprizes the usual roughing and finishing train driven direct

by a powerful engine, with two cylinders 50 inches in diameter and 4½ feet stroke, capable of developing 5,000 horsepower. A 25 tons electrically-driven overhead crane serves the cogging and girder-mills.

All bars, joists, etc., after being cut by the hot saws, are transferred to the electrically-operated hot-skid cooling-benches; and are loaded either direct into wagons, or transferred to the large finishing shed, 120 feet wide and 300 feet long. Two 5 tons electrical overhead cranes cover the whole area of the shed. The high-speed saw, 3½ feet in diameter, driven by a motor of 135 horsepower, will cut a joist, 12 inches by 6 inches, when cold, in less than 1 minute.

Shelton Iron-and-steel Works.

All the well-known brands of bar-iron are made at the Shelton forge, and rolled to various sections at the adjacent small mills. Small steel sections are also rolled here. In addition to the two forges, there are three bar-mills, with rolls 16 inches, 12 inches and 10 inches in diameter respectively; a light plate-mill, with rolls 22 inches in diameter; and a sheet-mill, with rolls 21 inches in diameter.

There are also foundry, fitting, locomotive and wagon repairing shops.

SNEYD COLLIERIES, LIMITED.

There are three coal-drawing pits and one upcast pit.

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No. 4 pit, sunk to a depth of 2,643 feet, is working the Cockshead, Holly Lane and Bowling Alley seams. The winding-engine has two cylinders, 42 inches in diameter and 7 feet stroke, and a parallel drum 24 feet in diameter. Hydraulic tub-changing apparatus is provided both at the surface and underground; and eight wagons, in a four-decked cage, are changed simultaneously. At present, however, two-decked winding cages are in use, holding four wagons.

The ventilation is accomplished by means of a rope-driven Walker fan, 24 feet in diameter, having a capacity of 350,000 cubic feet of air, with a water-gauge of 5 inches, when running at 120 revolutions per minute.

The power-house contains two steam-driven alternators, each of 250 kilowatts capacity, and a direct-current plant, for lighting and excitation, of 50 kilowatts capacity. A Rateau exhaust-steam turbine, connected to a three-phase alternator of 500 kilowatts capacity, is in process of erection. All the auxiliary machinery underground, and most of it on the surface, is operated by about thirty three-phase motors, varying from 3 brake-horsepower to 150 brake-horsepower.

The screening-plant, recently constructed of the most modern type, comprizes four tipplers arranged for dealing with the various classes of fuel. The main coal belts are of bar construction, so that any slack coal made on the belt is removed before the coal is delivered into the truck. Jib-ends, operated by an electric motor, are provided at the ends of the belts.

Steam is provided by nine Lancashire boilers, with natural draught, the chimney being over 200 feet high. Superheaters are attached to eight of the boilers, the average amount of superheat imparted to the steam varying from 130° to 150° Fahr.

The range of shops comprizes a smithy, with four fires and an electrically-driven power-hammer, saw-mill, joiner's shop and fitting-shop.

STAFFORD COAL AND IRON COMPANY, LIMITED.

The works of the Stafford Coal and Iron Company, Limited, are situated about 2 miles from Stoke-upon-Trent. They consist of two groups of pits, blast-furnaces, chemical works and brick-works.

No. 1 Colliery.

The Pender and upcast shaft, 13 feet in diameter, is sunk to a depth of 1,028 feet. The Great Row coal-seam, 8 feet thick, is proved at a depth of 851 feet, and the coal is drawn from the Woodmine inset at a depth of 980 feet. The shaft is fitted with eight wire-rod guides, four to each of the double-decked cages, taking two tubs on each deck, about 10 cwts. of coal being carried in each tub. The head-gears are made of steel lattice-girders, 60 feet high. The vertical winding-engine, with two cylinders, each 36 inches in diameter and 6 feet stroke, works a conical overhead drum, 18 to 21 feet in diameter.

The Kemball and downcast shaft, 16 feet in diameter, is sunk to a depth of 1,030 feet. The Basseymine ironstone (from 1 foot to 6 feet thick, resting on a seam of coal 2 feet 6 inches thick) is proved at a depth of 662 feet, from which the stone is drawn. The shaft is fitted with guides and cages similar to those in the Pender shaft. The headgears are of timber 60 feet high. The winding-engine is of the same type and dimensions as that at the Pender shaft.

The Bourne and downcast shaft, 8 feet in diameter, and sunk to a depth of 1,054 feet, is used for water-drawing, and as a second outlet from the Great Row seam. The shaft is fitted with two wire-rod guides, one on each side of a double-decked cage carrying one tub on each deck. The headgears are of timber. The horizontal winding-engine, with two cylinders 22 inches in diameter and 4 feet stroke, works a cylindrical drum,

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clutch-gear near the pit-bottom. A second endless rope, working the level crut from the shaft to the junction of the two dips, is also driven off the clutch-gear in the pit-bottom. The clutch-gear is driven by a strap-rope carried down the Pender shaft from a compound haulage-engine, having cylinders, 22 inches and 38 inches in diameter respectively and 4 feet stroke, driving through gearing and clutches, two pulleys, one of which drives the Great Row haulage strap-rope, the other being intended to drive the endless-rope haulage in the Basseymine seam.

The endless-rope haulage in the Basseymine seam is driven direct by an engine on the surface. The ropes, carried down the Bourne shaft, work a dip about 2,100 feet long with an average gradient of 1 in 8. The rope works above the tubs, which are attached by means of lashing chains.

The ventilation of the Great Row and Basseymine seams is effected by a Walker fan, 24 feet in diameter, rope-driven from a tandem-compound engine, having cylinders 18 inches and 28 inches in diameter respectively and 4 feet stroke. This engine also drives a dynamo of 160 amperes at 220 volts: the current being used for lighting on the surface and in the pit-bottoms, and for driving a small pump in the Kemball shaft.

The steam is supplied by eight Lancashire boilers.

No. 2 Colliery.

The Sutherland and downcast shaft, 16 feet in diameter, is sunk 1,828 feet, recovering the Ash coal-seam, 6 feet 3 inches thick, at a depth of 1,780 feet, the coal being drawn from an inset made at this depth. The shaft is fitted with eight wire-rod guides, four to each of the double-decked cages, taking two tubs on each deck. The head-gears are made of steel lattice-girders 60 feet high. The winding-engine with two vertical cylinders, 36 inches in diameter and 6 feet stroke, drives an overhead conical drum, 20 feet to 23 feet in diameter.

The Homer and upcast shaft, 16 feet in diameter, is sunk 2,520 feet to the Moss coal-seam, which is not now being worked. The Ragmine ironstone is drawn at this shaft from the Knowles coal-seam inset at a depth of 1,455 feet. The Ragmine is a clayband ironstone, consisting of bands of dirt and stone, with a working-face of about 5 feet. The shaft-fittings and headgears

are similar to those at the Sutherland shaft. The winding-engine is similar to that at the Sutherland shaft, with the exception of the conical drum, which is smaller, having diameters of 18 feet to 21 feet.

The mechanical haulage in the Ash coal-seam consists of a main-dip rope from the surface, drawing up a dip to a point 360 feet from the pit-bottom, and a main rope electric haulage-gear drawing up a crut-dip to a point in the main dip 2,100 feet from the shaft. The main-dip rope is driven by an engine having two cylinders, 16 inches in diameter and 46 inches stroke, and a drum 4 feet in diameter. The rope is taken down the Sutherland shaft, and carried in troughs to the top of the dip. The journey consists of 21 loads. The dip, 3,000 feet long, has an average gradient of 1 in 8. The electrical haulage consists of a direct-current motor of 40 horsepower driving through belt-and-spur gearing, a drum, 3½ feet in diameter, drawing a journey of seven loads up the crut-dip, 900 feet long, with an average gradient of 1 in 5.

The ventilation of the Ash and Ragmine seams is effected by an open-running Waddle fan, 45 feet in diameter, driven by an engine with a single cylinder, 32 inches in diameter and 4 feet stroke.

Steam is supplied from a range of nine gas-fired Lancashire boilers.

Electrical Plant.

Blast-furnaces and Bye-product Recovery-plant.

There are four blast-furnaces 65 feet high. The blast is supplied by one vertical blowing-engine, with a steam-cylinder 40 inches in diameter, and an air-cylinder 90 inches in diameter and 5 feet stroke; also by two vertical blowing-engines, with steam-cylinders 33 inches in diameter and air-cylinders 66 inches in diameter and 4½ feet stroke. There are also in reserve two vertical blowing-engines, with steam-cylinders 32 inches in diameter and air-cylinders 78 inches in diameter and 4 feet stroke.

The furnace-gases, on leaving the blast-furnaces, are taken to the bye-product works, where pitch, oils and ammonium sulphate are obtained. The washed gas is used for heating the blast for the furnaces and for raising steam.

Steam for the blast-furnace plant is supplied by a battery of nine gas-fired Lancashire boilers, and the bye-product works are supplied by a battery of six gas-fired Lancashire boilers.

Brickworks.

The marl for brickmaking is brought from a marl-hole to the brickworks by a single-span aerial ropeway. The marl is treated in a Swinney brickmaking machine with a double-ended pug, making wire-cut bricks, which are dried in a drying-shed heated by slack-fired flues. The bricks are fired in eight kilns.

Surface-works.

The surface-works comprize mine-hearths, shops, stores, iron-foundry, brass-foundry, and the usual railway-sidings. Two locomotives are employed in shunting, etc., and one is employed in conveying the slag from the furnaces to the cinder-tip. There are carpenters', pattern-makers', blacksmiths', fitters', boiler-makers', electricians' and locomotive-repairers' shops. The shafting, driving most of the machines in the shops, is driven by a horizontal engine with a single cylinder 10 inches in diameter and 12 inches stroke.

The machines in the fitting shop are served by a runway fitted with 1 ton blocks.

Florence Colliery.

The seams worked comprize the Main coal, 6 feet thick; the Moss coal, 5 feet thick; and the Yard coal, 7 feet thick. The coal is wound from two shafts, 165 feet apart.

The No. 1 and upcast shaft, 12½ feet in diameter, is sunk to a depth of 2,538 feet. The shaft is fitted with wooden conductors to a depth of 1,800 feet, from which depth the Main coal-seam is wound. There are two three-decked cages taking two tubs of coal on each deck, each tub carrying about 10 cwts. of coal. The Lang-lay winding-ropes are 4½ inches in circumference, and their weight is partly balanced by a flat rope, suspended below the cages.

The horizontal winding-engine has two cylinders, 30 inches in diameter and 6 feet stroke, fitted with Cornish valves and Barclay trip-gear. The parallel drum, 16 feet in diameter, has a brake-path on each side, and is fitted with the Whitmore steam-brake and over-winding device. Steam, used at a pressure of 80 pounds per square inch, is generated in a range of five boilers, three of which are fitted with superheaters.

The No. 2 and downcast shaft, 14 feet in diameter for a depth of 2,100 feet, and gradually bellied out from this depth to 17 feet in diameter at 2,670 feet, is fitted with wire-rod guides to a depth of 2,580 feet, at which depth coal is drawn from the Moss and Yard seams. The four-decked cages take two tubs on each deck: two decks being loaded simultaneously. Decking is performed at two landings at the top and bottom of the shaft: at the top, the empty tubs are brought to the top-decking landing by means of a creeper, the loads gravitating to the screens; and at the bottom the loads are lowered to, and the empties raised from, the bottom decking-landing by gravity-cages. The locked-

[redacted]

100,000 cubic feet of air per minute at 2 inches of water-gauge. The fan is driven by a horizontal engine, with a single cylinder 32 inches in diameter and 4 feet stroke.

In the Main coal-seam, the mechanical haulage consists of two endless under-tub ropes and a main-dip rope. An endless rope driven by an electrical haulage-set of 60 horsepower near the pit-bottom, hauls along a level 2,820 feet long, and down a crut 840 feet long to the shaft. The second endless rope, delivering to the top of the main crut from a level 1,410 feet long, is driven from a haulage-set by an electric motor of 10 horsepower. The main-dip rope, driven by a haulage-set of 60 horsepower, draws up a dip 1,620 feet long with an average gradient of 1 in 5.

In the Yard coal-seam, most of the workings are to the rise of the pit-bottom, and the haulage is performed by self-acting endless-rope inclines. A main jig, 2,580 feet long and driven upward at a gradient of 1 in 8, is worked by a self-acting endless rope. The coal from the main jig is lowered to the pit-bottom down a crut-jig, 360 feet long with a gradient of 1 in 5, by a self-acting endless rope, which also takes the coal from a district in the Moss coal-seam. The coal from this district is brought along a level, and down a crut having a gradient of 1 in 5, by an endless rope, driven from a haulage-set by an electric motor of 10 horsepower. A second district in the Moss seam is reached by a level crut driven out, from near the shaft, for a distance of 1,050 feet. This crut is worked by an endless rope, driven from a haulage-set by a motor of 60 horsepower. In addition to the above main haulage-systems, there are several portable haulage-sets, working dips and slants in process of extension.

Four electrically-driven diamond coal-cutters are at work. In the Main coal-seam, two machines of 24 horsepower are cutting 1,500 feet and 1,050 feet of longwall-face respectively. In the Moss coal-seam, machines of 24 and 32 horsepower respectively are cutting 3,000 feet of longwall-face between them.

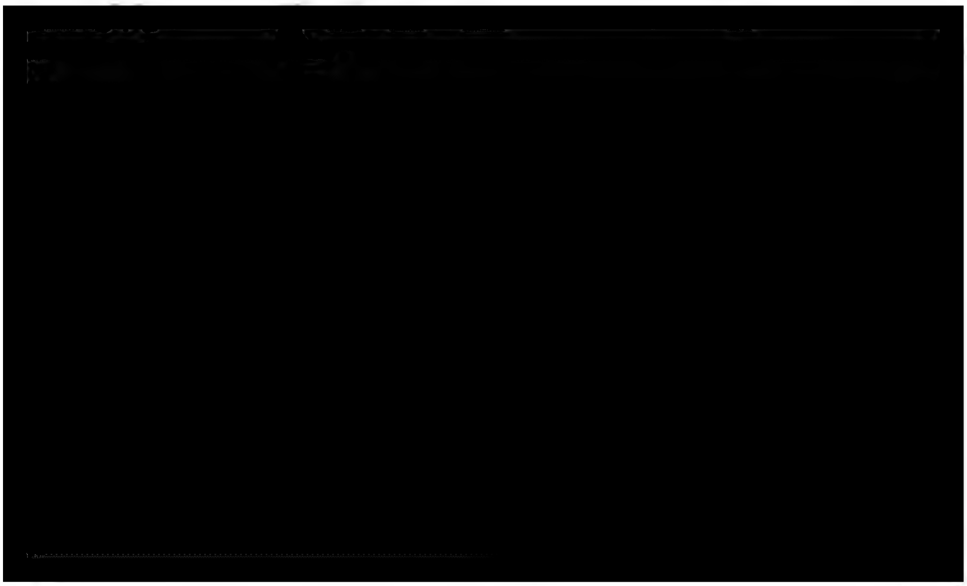
The water from the shaft is collected in a water-lodge, at a depth of 480 feet in No. 2 shaft, from which it is pumped to the surface by a three-throw pump, with rams 5½ inches in diameter and 9 inches stroke, driven by an electric motor of 25 horsepower.

The pit-bottom water, small in quantity, is pumped by a three-throw electrically-driven pump from a depth of 2,400 feet to the water-lodge in the shaft, against a head of 2,100 feet.

The best coal from No. 2 pit is sent to a three-tubs gravity tippler, and delivered upon a travelling belt. The best coal and cobbles are picked off this belt into trucks by hand, and the remainder is conveyed by the belt to a shaking screen separating it into four sizes. The three larger sizes are each delivered by separate picking-belts on to a fourth belt. The slack from the shaker is conveyed to one compartment in the coal-storage tower for the washery.

The coal from No. 1 pit (and some coal from No. 2 pit) is taken to two friction-driven tipplers delivering upon shaking screens. The coal from these screens is discharged on to two picking-belts; and the slack is conveyed to the other compartment of the coal-storage tower for the washery. The coal from the storage-tower is delivered by two conveyors to two side shaking-screens at the top of the washery, which has a capacity of 50 tons per hour.

The screens, in the washery, classify each kind of coal into four sizes, the three larger sizes of each sort being treated in two sets of three nut-washers for steam and house coals respectively, and two kinds of fine coal are treated in two pairs of felspar-washers. The washed coal from the nut-washers is conveyed over draining screens and stored in separate hoppers. The fine coal from the felspar-washers is conveyed to any two of six fine-



into side-tipping wagons, and conveyed by an endless rope to the dirt-tip.

Direct current at a pressure of 550 volts is supplied to the pits and surface for power: and direct current at 110 volts is used for lighting on the surface. Direct current at 550 volts is generated by a compound-wound generator of 300 kilowatts driven by a Parsons turbine; and a generator of 115 kilowatts driven by an engine, with two cylinders 16 inches in diameter and 2 feet stroke, supplies current at 550 volts in the night-time when less power is required. The lighting current at 110 volts is generated by a direct-current generator, 160 amperes at 110 volts, driven by a motor, 42 amperes at 550 volts, on the same shaft. A steam-driven generator, 150 amperes at 110 volts, is kept in reserve for lighting purposes.

The steam used in the winding, fan and generator-engines is condensed in a central condensing plant capable of dealing with 78,000 pounds of steam per hour. The steam is led by a main, 30 inches in diameter, into an oil-separator. Thence it passes into two surface-condensers with 4,200 square feet of cooling surface each. The cooling water is circulated from the condensers through the cooling tower by two centrifugal pumps driven by two motors of 50 horsepower. The vacuum in the condensers is maintained by two air-pumps, with air-cylinders 22 inches in diameter and steam-cylinders 15 inches in diameter and 20 inches stroke. The connecting rods of this engine each drive, by means of levers, a wet pump, 9½ inches in diameter and 8½ inches stroke, and an oil-pump 3 inches in diameter and 8½ inches stroke. The condensed water from the hot well is pumped to the economizers by a pump.

THE INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

By Bennett H. Brough.*

The fourth Congress of the International Association for the Testing of Materials was held in Brussels, from September 3rd to 9th, 1906, and was brilliantly successful. The previous Congress was held in Budapest in 1901, and it had been arranged that the fourth Congress should be held in St. Petersburg in 1904; but, owing to the Russo-Japanese war and to the death of the President, Prof. L. von Tetmajer, the idea had to be abandoned.

Prior to the opening of the Congress, which took place on September 3rd, in the Palais des Académies, the King of the Belgians received the Council of the Association in an audience lasting an hour. At the opening meeting, Mr. Fr. Berger (Vienna), President of the Association, presided, and addresses of welcome were delivered by the Belgian Prime Minister and by the Secretary of the Department of Railways. Prof. F. Schüle (Zürich) read an address in memory of the deceased President, Ludwig von Tetmajer. Interesting papers were read on the history of the Belgian iron-industry by Baron E. de Laveleye, and on the Belgian cement-industry by Mr. Em. Camerman. The chief limestone-beds in Belgium are at Tournai, on both sides of the river Schelde, and produce annually 500,000 tons. The Belgian cement-works are consequently situated for the most part in the vicinity of Tournai: they produce annually 80,000 to 100,000 tons of Roman cement and 400,000 tons of Portland cement. In Belgium there is only one slag-cement works, namely, that at the Cockerill ironworks.

The titles of the reports and papers submitted to the three sections of the Congress were as follows:—

I.—OFFICIAL REPORTS.

[redacted]

"To establish uniform methods for testing cast-iron and finished castings." By Dr. R. Moldenke, New York.

"The progress of metallography since the Budapest Congress in 1901." By Mr. F. Osmond, Paris.

"The introduction of international specifications for testing and inspecting iron and steel of all kinds." By Dr. A. Rieppel, Nuremberg.

"Impact-tests on notched bars." By Mr. Ed. Sauvage, Paris.

B.—Natural and Artificial Building-stones and Cements.

"Accelerated tests of the constancy of volume of cements." By Mr. Bertram Blount, London.

"The decomposition of cements in sea-water." By Prof. H. Le Chatelier, Paris.

"Examination and valuation of the resolutions of the conferences of 1884 to 1893, concerning the adhesive strength of hydraulic cements." By Mr. R. Feret, Boulogne.

"Experiments made with a view of determining the methods for testing pozzuolanas." By Mr. R. Feret, Boulogne.

"Determination of a uniform method for the separation of the finest particles in Portland cement by liquid and air processes." By Prof. M. Gary, Gross-Lichterfelde-West.

"The relation of chemical composition to the weathering qualities of building-stones; the influence of smoke, especially sulphurous acid, on building-stones; and the weathering qualities of roofing-slates." By Prof. A Hanisch, Vienna.

"Trials of Swiss roofing-slate, together with some importations": (*a*) "The formation and texture of clay-slate," by Prof. Dr. A. Heim, Zürich; (*b*) "Results of physical-chemical researches," by the late Prof. L. von Tetmajer.

"To establish methods for testing pozzuolanas with the object of determining their value for mortars.' By Mr. G. Herfeldt, Andernach.

"Determination of the litre-weight of cement; the strength of real hydraulic cements; and the determination of a standard sand." By Prof. F. Schüle, Zürich.

"Tests for resistance to weathering of sandstones." By Prof. H. Seipp, Vienna.

C.—Other Materials.

"The methods of testing the protective power of paints used on metallic structures." By Mr. E. Ebert, Munich.

"Methods of testing pipes." By Prof. M. Gary, Gross-Lichterfelde-West.

"Raw and boiled linseed oil." By Mr. A. Grittner, Budapest.

D.—Miscellaneous.

"Unification of methods for testing materials." By Prof. N. Belelubsky, St. Petersburg.

"Methods of testing indiarubber." By Mr. Em. Camerman, Brussels.

"Uniform nomenclature of iron and steel." By Prof. H. M. Howe, New York, and Prof. Albert Sauveur, Cambridge, Massachus etts.

"Investigations of asphalt." By Messrs. V. Křepelka and F. Lunge, Zürich.

"Fixing a uniform definition and nomenclature of bitumen." By Prof. G. Lunge, Zürich.

"Principles of a standard method of testing wood." By Prof. Max Rudeloff, Gross-Lichterfelde-West.

"Proposals regarding tests for ascertaining a practicable method, applicable on a small scale, of showing the resistance of wood to putrefaction." By Prof. Max Rudeloff, Gross-Lichterfelde-West.

"Tests to determine the durability of wood." By Dr. C. von Tubeuf, Munich.

II.—NON-OFFICIAL PAPERS.

A.—Metals.

"Punching as a testing method." By Mr. L. Baclé, Paris.

"Remarks on the influence of the shape of the saw-notch in the present method of testing for fragility." By Mr. F. Barbier, Paris.

"The allotropic transformations of nickel-steels." By Mr. O. Boudouard, Paris.

"Determination of the points of allotropic transformation in iron and its alloys by measurements of the variations in their electrical resistances at different temperatures." By Mr. O. Boudouard, Paris.

"Examination of various metals by the Brinell method." By Mr. P. Breuil, Paris.

"The phenomena of deformation and rupture in iron and mild steel." By Messrs. G. Cartaud, Ch. Frémont and F. Osmond, Paris.

"Testing metals by bending notched bars." By Mr. G. Charpy, Montluçon.

"Influence of temperature on the resistance of metals." By Mr. G. Charpy, Montluçon.

"Determination of the degree of fragility and of homogeneity of rail-steel by impact-tests with notched bars." By Prof. S. Drouginine, St. Petersburg.

"New magnetic test-methods." By Mr. L. Fraichet, Puteaux.

"A new apparatus for automatically drawing the load-strain diagram due to impact." By Prince A. Gagarine, St. Petersburg.

"A new dynamometer: limit of elasticity used for measuring forces and description of a machine for compression-, tensile- and bending-tests." [redacted]

"Graphic representation of the process of setting in the case of cements." By Prof. M. Gary, Gross-Lichterfelde-West.

"New weathering tests with natural stones." By Prof. M. Gary, Gross-Lichterfelde-West.

"Experiments on the elasticity of Sicilian limestones." By Mr. M. Greco, Palermo.

"The shearing strength of cement-mortars." By Mr. M. Greco, Palermo.

"The normal consistency of cement-mortars." By Mr. J. Malüga, St. Petersburg.

"Trials made at La Rochelle on the action of sea-water on mortars." By Mr. E. Mayer, La Rochelle.

"The necessity of modifying the process actually followed in analysing cement-mortars and in sampling them." By Mr. E. Maynard, La Rochelle.

"Mechanism of the deterioration of cement-mortars, and the rapid determination of their behaviour in the sea by the manner in which they decompose." By Mr. E. Maynard, La Rochelle.

"The resistance of stone to compression, with elastic substances interposed between the surfaces in compression." By Prof. G. S. Pace, Palermo.

C.—Other Materials and Miscellaneous.

"The mechanical examination of manufactured indiarubber." By Mr. P. Breuil, Paris.

"Tests with steam, gas and water-tubes." By Prof. H. I. Hannover, Copenhagen.

"Relation of timber-tests to forest-products." By Prof. W. K. Hatt, Lafayette, U.S.A.

"Asphalt-tests." By Mr. Holde.

"Making the neutral axis visible by means of circularly polarized light." By Mr. O. Hönigsberg, Vienna.

"Frictional resistance on lubricated surfaces." By Prof. F. Kick, Vienna.

"A simple method of adapting the principle of automatic registration to lever-testing machines." By Mr. M. Mesnager, Paris.

"Transmission of forces to the interior of elastic solids." By Mr. M. Mesnager, Paris.

The section dealing with metals was presided over by Mr. J. Magery (Namur), and he was supported by honorary presidents, representing the various nationalities present, and including Messrs. S. Popper (Austria), E. Saladin (France), H. Wedding (Germany), Bennett H. Brough (Great Britain), P. A. M. Hackstroh (Holland), D. Chernoff (Russia), J. Tonello y Rabassa (Spain) and J. A. Brinell (Sweden).

The discussions were well sustained, particularly in reference to the value of welding-tests, of impact-tests with notched bars, and of Brinell hardness-tests. Although the report of the Committee was to the effect that it was not feasible to establish standard welding-tests, the Congress expressed the wish that the problem should be further studied, and that opportunity should be given for carrying out scientific researches on the nature of welding. As regards impact bending-tests with notched bars, the views expressed were widely divergent, but the Congress agreed that this method of testing appeared capable of yielding very interesting results. The Brinell ball-test for hardness was more generally approved, the Congress resolving unanimously that it was desirable that, in addition to

tensile tests, Brinell hardness-tests should be made as frequently as possible, with a view to recording information.

The section on cements was presided over by Mr. M. Levie (Charleroi), and the miscellaneous section was presided over by Mr. E. Roussel (Malines).

In the report on the nomenclature of iron and steel, Prof. H. M. Howe (New York) and Prof. A. Sauveur (Harvard University) expressed the view that it would be well to decide on a definite carbon-content to serve as a boundary line between ingot-iron and ingot-steel, between puddled iron and puddled steel, and between any other varieties of wrought iron and weld-steel. Two plans had been considered. One was to draw this line at 0·32 per cent. of carbon or its equivalent in other elements, for the reason that this carbon-content appears to correspond to the critical point in the diagrams of Sir W. Roberts-Austen and Prof. H. W. B. Roozeboom. This had the merit of corresponding to a definite physical boundary. The other plan was to draw the boundary at 0·20 per cent. of carbon, because this was a convenient point to separate the important classes "soft steel" and "half-hard steel," so that if this point were adopted, "ingot-iron" would be synonymous with "soft steel," and "ingot-steel" would be the equivalent of the two classes " half-hard steel " and " hard steel."

For tests of hydraulic cements, the Congress resolved unanimously to recommend the employment of prismatic test-pieces measuring 4 centimetres by 4 centimetres by 16 centimetres (1·58 inches by 1·58 inches by 6·30 inches), to be tested first by bending and then by compression between steel plates 4 centimetres (1·58 inches) in width. The normal sand should be, if possible, a quartzose natural sand, obtained between screens of 64 and 144 apertures per square centimetre (about 412 and 930 apertures per square inch). The normal sand from Freienwalde is especially recommended. The test should be made with six test-pieces prepared simultaneously in a plastic condition, preserved in the mould for 24 hours in a moist atmosphere, and placed under water until the moment of the test. The recent development of the use of armoured cement was not ignored by the Congress, and after considerable discussion a committee was appointed to investigate the matter.

The recommendations made by Prof. Max Rudeloff (Berlin) regarding tests of wood were accepted, with the modification that the normal pro- [redacted]

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

ANNUAL GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
OCTOBER 9TH, 1906.

MR. HENRY BRAMALL, RETIRING PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. JOHN HENRY CHILCOTE BROOKING, Mechanical and Electrical Engineer, 85, Northumberland Road, Old Trafford, Manchester.

Mr. CLEMENT FLETCHER, Mining Engineer, The Hindles, Atherton, near Manchester.

Mr. ALBERT EDWARD MILLWARD, Mining Engineer, Manchester Road, Accrington.

ASSOCIATE MEMBER—

Mr. MARCEL DUBOIS, 6, Rue Gounod, Paris, XVII., France.

STUDENT—

Mr. WALTER PEARCE, Mining Student, 1, Green Lane, Heaton Moor, Stockport.

The HONORARY SECRETARY (Mr. Sydney A. Smith) read the Annual Report of the Council as follows:—

ANNUAL REPORT OF THE COUNCIL, 1905-1906.

In presenting the sixty-eighth Annual Report (the second since the federation of the society with The Institution of Mining Engineers) the Council have pleasure in congratulating the members upon another successful session.

The Honorary Treasurer's statement of accounts shows that the financial position of the society is thoroughly satisfactory, although, during the year, heavy expenditure has been incurred in providing the rooms with additional furniture, etc. The increased amount of subscriptions of federated members is a noteworthy item.

During the year the elections to membership have been as follows:—1 honorary member, 10 federated members, 2 federated associate members, 3 federated student members, and a total increase of 16.

Nine members, non-federated, have been transferred to the federated members' and 1 to the associates' list; and 1 federated member has been transferred to the non-federated members' list. The withdrawals by death, resignations and other causes have been 1 honorary member, 5 federated members and 10 non-federated members.

The following table shows the changes in the list of members for the year, from which it will be noted that the number of federated members has increased to 211 as compared with 187 on last year's list, an increase of 24 during the year.

The classification of the membership for the year 1905-1906 is shown in the following table:—

Classification.	Non-federated Members.	Federated Members.	Totals.
Honorary Members	12	—	12
Members, inclusive of Life Members	63	192	255
Associate Members	—	5	5
Associates	—	3	3
Students	—	11	11
Totals ...	75	211	286

While your Council are happy in having to record a smaller number of deaths during the past year than on many former [redacted]

tax on coal, and, dealing with the question of wages as a factor in the cost of production, submitted that the high standard of wages now maintained rendered it imperative that such costly labour should be utilized to the best advantage by the adoption of any improvements (mechanical or otherwise) tending to reduce the amount of labour, or to make it more efficient, and consequently more economical. Mr. Bramall indicated a number of ways, in which he thought economies might be effected.

In addition to the annual meeting, eight ordinary meetings have been held in the Society's rooms, and one excursion meeting has also been held during the year. The average attendance has been very good.

During the session, important papers on geological subjects were read by Mr. Joseph Dickinson, Mr. John Gerrard and Mr. William Watts; mine engineering has been the subject of papers by Mr. William Watts, Mr. Alfred J. Tonge and Mr. James Ashworth; and the application of electricity in collieries has been dealt with by Mr. Gerald H. J. Hooghwinkel and Mr. P. Barrett Coulston.

The following is a complete list of papers and short communications brought before the Society during the year 1905-1906, and published together with the discussions thereon in its *Transactions*, and also in the *Transactions* of The Institution of Mining Engineers:—

"The Elba and Clydach Vale Colliery Explosions." By Mr. James Ashworth.

"Presidential Address." By Mr. Henry Bramall, M.Inst.C.E.

"The Use of Electricity in Collieries." By Mr. P. Barrett Coulston, M.I.E.E.

"The Origin of Fossil Life." By Mr. Joseph Dickinson, F.G.S.

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"Report of Delegate to Conference of Delegates of Corresponding Societies of the British Association for the Advancement of Science, London, 1905." By Mr. William Watts, Assoc.M.Inst.C.E., F.G.S.

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Mr. John Gerrard exhibited specimens of fossil shells from the marine bed (at a depth of 2,076 feet) at Bradford colliery, and also specimens from the marine bed in the banks of the river Tame at Dukinfield.

A joint excursion of the members of this Society and of the North Staffordshire Institute of Mining and Mechanical Engineers, was made, on July 30th, to the No. 4 Atherton pit of the Hulton colliery; and, under the leadership of Mr. Alfred J. Tonge, 73 members and friends inspected the underground fans described in Mr. Tonge's paper, "Underground Fans as Main Ventilators," and the electrical equipment and other plant as described in the account of the excursion issued in the *Transactions*. The Society is indebted to the Hulton Colliery Company, Limited, for the excellent arrangements made for the convenience of the party on that occasion.

The following papers, printed in the *Transactions* of the Institution of Mining Engineers, have been discussed at the Society's meetings:—

"The Mickley Conveyor." By Mr. J. W. Batey.*

"The Conveyor-system of filling at the Coal-face, as Practised in Great Britain and America." By Messrs. W. C. Blackett and R. G. Ware.†

Last year, it was the privilege of this society that one of its members, Sir Lees Knowles, Bart., was elected as President of The Institution of Mining Engineers, for the year 1905-1906. Sir Lees Knowles has performed the duties of this office with dignity, and to the great satisfaction of the members of the [redacted]

Considerable improvements and additions to the library have been made during the year, several new book-cases and book-shelves have been provided, and a new catalogue of the books, maps and periodicals is being compiled, and will shortly be issued to the members. Reference to the valuable publications of the United States Geological Survey has also been greatly facilitated by the use of the card-index, and it is hoped that members will avail themselves of these increased facilities by making free use of the library.

The thanks of the Council are tendered to the authors of the various papers and other communications, for their valuable contributions to the work of the Society, and, in conclusion, the Council desire to impress upon every member the desirability of taking a still greater interest in this work, by regularly attending the meetings, by introducing new members, and by bringing forward any matter which would be of interest to the Society and to The Institution of Mining Engineers.

The Statement of Accounts was presented on behalf of the Honorary Treasurer (Col. George H. Hollingworth) as annexed.

The CHAIRMAN (Mr. H. Bramall) moved the adoption of the Council's Report and Balance Sheet.

Mr. ROBERT WINSTANLEY seconded the resolution, which was unanimously approved.

ELECTION OF OFFICERS, 1906-1907.

The following officers were unanimously elected for the ensuing year:—

PRESIDENT:
Mr. CHARLES PILKINGTON, J.P.

VICE-PRESIDENTS:

Mr. JOHN ASHWORTH, C.E.	Mr. ALFRED J. TONGE.
Mr. GEORGE B. HARRISON, H.M.I.M.	Mr. GEORGE H. WINSTANLEY, F.G.S.

HONORARY TREASURER: Mr. GEORGE H. HOLLINGWORTH, F.G.S.

HONORARY SECRETARY: Mr. SYDNEY A. SMITH, Assoc.M.Inst.C.E.

[redacted] THE MANCHESTER GEOLOGICAL AND MINING SOCIETY, FOR THE YEAR ENDING SEPTEMBER 30TH, 1906. CR.

	£	s.	d.		£	s.	d.
[redacted] ...	131	19	4	Sept. 30th, 1906.			
[redacted] ..	2	6	4	By Rent, wages, and expenses of rooms	160	4	5
[redacted] s. d.				,, Printing and stationery	22	9	2
[redacted] 3 0				,, Postages, etc.	22	17	8
[redacted] 3 0				,, Reporters	9	9	0
[redacted] 6 0	471	12	0	,, Library	3	18	1
[redacted] 16 0				,, New furniture	34	16	6
[redacted] 17 10	43	13	10	,, Sundry expenses	16	17	9½
[redacted] ...	2	16	9	,, The Institution of Mining Engineers	275	12	7
[redacted] ...	12	11	0	,, *Transactions*, 1904-1905	4	17	6
[redacted] .	3	18	0	,, Expenses of meetings	24	5	0
				,, Balance in bank	89	13	4
				,, ,, in Secretary's hands	3	16	2½
	£668	17	3		£668	17	3

Library Fund.

Dr.				Cr.	£	s.	d.
				Sept. 30th, 1905. ,, Balance ...	1	13	9

Balance Sheet, September 30th, 1906.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
Outstanding accounts, say ...	22	10	11	£600 Birkenhead Railway 4 per cent. Consolidated Preference Guaranteed Stock, at £118 ...	708	0	0
Balance in favour of the Society ...	1,984	12	4	£733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock, at £86½	634	0	0
				Library and furniture ...	500	0	0
				Cash in bank ...	89	13	4
				,, in Secretary's hands ...	3	16	2
				Arrears of subscription, £98, say ...	70	0	0
				Balance of Library Fund ...	1	13	9
	£2,007	3	3		£2,007	3	3

The Investments of the Society consist of £600 Birkenhead Railway 4 per cent. Consolidated Preference Guaranteed Stock, and £733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock. The certificates for these are deposited at Messrs. Williams Deacons Bank, Limited, St. Anne's Street, Manchester, and were inspected by us on October 3rd, 1906.

Audited and found correct, October 9th, 1906.

Geo. H. Hollingworth,
Honorary Treasurer.

Jon. Barnes,
G. H. Winstanley, } *Honorary Auditors.*

COUNCILLORS:

Mr. H. STANLEY ATHERTON.
Mr. E. O. BOLTON.
Mr. C. F. BOUCHIER.
Mr. VINCENT BRAMALL.
Mr. W. OLLERENSHAW.
Mr. WILLIAM PICKSTONE.
Mr. P. C. POPE.
Mr. JOHN ROBINSON.
Mr. W. H. SUTCLIFFE, F.G.S.
Mr. JESSE WALLWORK.
Mr. PERCY LEE WOOD.
Mr. T. H. WORDSWORTH.

HONORARY AUDITORS:

Mr. J. BARNES, F.G.S.
Mr. GEORGE H. WINSTANLEY, F.G.S.

Mr. JOHN GERRARD (H.M. Inspector of Mines) said that he proposed Mr. Bramall's election a year ago, and then said that Mr. Bramall would be the right man in the right place. He was sure that the members, during the past year, had found those words to be true; no one could have better filled the office of President than Mr. Bramall had done, and it was only fitting that they should express their appreciation. He therefore proposed that they express to Mr. Henry Bramall their sincere and hearty thanks for the admirable manner in which he had performed his duty as President of the Society.

Prof. W. BOYD DAWKINS, in seconding the proposal, said that he was expressing the feelings of every member when he said that they were extremely grateful to Mr. Bramall, their retiring President, for the way in which he had conducted the business of the Society during the past year.

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great pleasure in moving that the best thanks of the Society be accorded to Mr. Sydney A. Smith for his services as Honorary Secretary during the past year. Without Mr. Sydney A. Smith's assistance, the President would have given but poor satisfaction; and he thought, really, that greater thanks were due to Mr. Smith, who did everything within his power to promote the interests of the Society.

Mr. Geo. B. Harrison (H.M. Inspector of Mines), in seconding the motion, said that he had seen, perhaps, more of the Honorary Secretary's work than the President.

The resolution was passed with cheers.

FOSSIL-SHELLS FROM CHORLEY.

Mr. John Gerrard (H.M. Inspector of Mines) exhibited shells obtained from the Mountain mine measures at Chorley. One series from a marine bed comprized *Pterinopecten (Aviculopecten)*, *Dimorphoceras* (Goniatites), *Posidoniella*, etc. Another series from a fresh-water bed comprized *Carbonicola robusta*, *Carbonicola acuta* and *Carbonicola aquilina*. A seam of coal had been worked for some years at Chorley, and called the Mountain mine; and recently a shaft had been sunk from this seam, about 270 feet in depth, and a lower seam of coal had been found. The marine shells were found about 63 feet below the upper seam and about 1 foot below a coal-seam, 10 inches thick. The freshwater shells were found about 5 feet above the lower seam. The problem to be decided was whether the Upper seam corresponds to the Upper Mountain mine and whether the Lower seam corresponds to the Lower Mountain mine. The position of the marine bed was different from that of the marine bed in the Billinge section; or in the Rochdale, Bacup, Burnley and Accrington sections; or in the Halifax and Yorkshire sections. He (Mr. Gerrard) hoped that it might be possible to bring before the society a section of the sinking. He was indebted to Mr. James Cunliffe, the manager of the colliery, who had very kindly enabled him to obtain the specimens.

Mr. Joseph Dickinson thought that the shells were similar to those which guided Mr. P. W. Pickup in cutting through the fault at Rishton colliery.

Mr. H. STANLEY ATHERTON said that at Chorley colliery, about 150 feet above the top workable mine, there was a self-faced flag-bed, which was very similar to that found at Spring Vale, near Darwen, This discovery was the first means of its identification in the section of the Burnley coal-field.

COAL IN KENT.

Prof. W. BOYD DAWKINS exhibited some specimens of coal recently found at Waldershare, in Kent. Three seams were found:—The first seam, 20 inches thick, at a depth of 1,818 feet 7 inches; the second seam, 40 inches thick, at 1,881 feet 4 inches; and the third seam, 54 inches thick, at 1,908 feet 9 inches. The seams rested upon fire-clay floors and had hard bind roofs. These coal-seams, discovered in a new locality, proved the truth of the observations which he had addressed to the Society since the year 1886. He hoped, at some future time, to give the Society the results of his enquiry into the range of the coal-fields of Somerset and South Wales, eastward into Kent.

DISCUSSION OF MR. A. J. TONGE'S PAPER ON "UNDERGROUND FANS AS MAIN VENTILATORS."*

Mr. H. W. G. HALBAUM (Birtley) wrote that Mr. Tonge's system of placing the fans belowground certainly had two strong [redacted]

the fans belowground, it was not at all clear that, on the whole, the system was superior to the ordinary practice of placing the plant entirely aboveground. One serious objection to Mr. Tonge's method was that it made the upcast shaft the seat of the higher pressure, as compared with the downcast column; and that, in fact, appeared to be an evil inseparably associated with the system. The first result of that difference of shaft-pressures was to establish a minus water-gauge against the entire ventilation of the pit. The second result was that the inevitable leakage through the separation-doors (Plate V.*) was not, as under the surface-fan system, a comparatively harmless leakage of fresh air from the downcast shaft to the upcast shaft, but a most objectionable and even dangerous leakage of foul air and gases from the upcast shaft into the great trunk intake-currents of the mine or mines. In the event of an accident to any one set of separation-doors, the result would inevitably be the wholesale fouling of the entire ventilation. Members would readily perceive the real force of that objection by reflecting that, under Mr. Tonge's method, the pressure of any given layer of air in the upcast shaft must necessarily exceed that of the outer atmosphere, whilst the pressure of any given layer in the downcast shaft must necessarily be less than that of the outer atmosphere. In each case, the difference of pressure obtaining between the given layer and the atmosphere would be equal to the pressure due to friction in the shaft overhead. In the upcast shaft, that difference was plus, while in the downcast shaft, the difference was minus, so that the motive column of leakage from the upcast shaft to the downcast shaft in any given horizontal plane was equal to the motive column expended on friction in both shafts above the given plane.

One could not pass over the possibility of accidents to separation-doors, it was a contingency that should not be left out of account, and the possibility was by no means a remote one. Consider the case, say, of the A seam. It followed from the character of the differential shaft-pressures that, under Mr. Tonge's system, the separation-doors would require to be hung so as to open against the superior pressure in the upcast shaft. A slight coal-dust explosion on the main intake-airway of the A seam would, just like other similar blasts, travel against the wind and back

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 218.

to the downcast shaft. Its momentum would carry it across that shaft, and it would collide with the separation-doors, throwing them open with more or less violence, and very possibly damaging them to such an extent as to render them useless. The blast of such a minor explosion, or even the shock of a heavy shot blown out on the intake-airway might do so much, and yet leave the fan at the other side of the upcast shaft uninjured. In such a case, the still-revolving fan would exhaust the noxious fumes from the intake air-way by way of the workings, and passing them through itself would expel them, for the greater part, through the frames of the broken doors, into the downcast shaft; and it would do this simply because, under Mr. Tonge's system, the downcast shaft was a region of much lower pressure than the upcast. Under the ordinary surface-fan arrangement, an accident to the separation-doors merely suspended the ventilating current in the working-places; but Mr. Tonge's method, under similar circumstances, positively transformed the current into a death-dealing engine of destruction. That consideration appeared to furnish a fatal objection to the use of underground fans as main ventilators for fiery or dusty mines. Under such a system, the provisions of the Coal-mines Regulation Act would require to be reversed, and matters would have to be so arranged that any explosive blast capable of injuring the separation-doors should instantly and automatically put out of action the entire series of fans at work underground. Otherwise, pending the getting to work of the stand-bye plant at the surface, the whole [redacted]

to a kind of preferential stock upon which constant uniform dividends had to be paid, irrespective of the question as to whether the ventilating plant were placed on the surface or underground. The utmost that could be attempted was to save a percentage of that which was itself a mere percentage of the total cost. From that point of view, such illustrations as that of the five mines requiring from 1 to 5 inches of water-gauge each,* where the one system costs 66 per cent. more than the other, seemed to be singularly far-fetched and unpractical. Neither Mr. Tonge nor any other engineer could save 60 per cent. of a sum, of which 60 per cent. was already paid away, and of which a further percentage was required for actual necessaries.

Furthermore, if one referred to Table I.† it appeared that the practical economical results were as shadowy as the theoretical illustrations. It was there recorded that 25 horsepower in the air were obtained from 69 brake-horsepower of the motors. Those practical results accruing from Mr. Tonge's method should be compared with the over-all efficiencies lately obtained by motor-driven fans of the Waddle and of the Capell types working under the ordinary system.

He (Mr. Halbaum) could not help feeling sceptical with regard to the claims advanced, on the score of largely increased economy, for Mr. Tonge's system of underground fans. Because (1), as previously stated, that system of ventilation began, owing to its unhappy distribution of shaft-pressures, by setting up a water-gauge against its own work. (2) Air was a material that required to be handled very gently, and Mr. D. Murgue had laid it down, as the first principle of fan-design, that the machine should receive the air without shock. The air at a regulator, again, was practically killed by shock. Hence, it was notorious that shock was, in the case of all gaseous fluids, a merciless destroyer of pressure. Instead of a moderately sized fan at the surface, Mr. Tonge had installed three small fans underground; the diameters varied from 30 to 45 inches, and the revolutions from 400 to 600 feet per minute. Under present conditions the fan on the A mine was 30 inches in diameter and the water-gauge at 580 revolutions per minute was ⅞ inch. The useful water-gauge was therefore, about one-third of the theoretical water-gauge

* *Trans. Inst. M. E.*, 1906, vol. xxxi., pages 211 and 212.

† *Ibid.*, vol. xxxi., page 209.

due to that speed of the periphery: most of the rest being destroyed by shock, as at an ordinary regulator. The acceleration which it was attempted to impart to the air was unreasonable, and was inseparable from disastrous shock. Mr. Tonge claimed that he had done away with regulators. The truth was that he had simply called the real regulator by another name: his regulator was a more wasteful machine than the ordinary one, for it created by power, and then destroyed by power, a greater surplus of pressure than the difference required as between the seam of minimum drag and that of maximum drag. It was such gratuitous wastes of power that largely accounted for the fact that 69 brake-horsepower were required at the motors to generate 25 horsepower in the air as shown in Table I.*

Mr. Tonge further spoke of "the convenience of being able to regulate the supply of air in one mine, as in the case of the underground fans, without affecting any other;"† and that discovered at once the profound fallacy of which Mr. Tonge had become enamoured. The fact was that, at Hulton colliery, the ventilating plant consisted of three units, each one of which continually reacted against the other two. It was the case at all collieries that the ventilation of one seam reacted against the ventilation of all the others, but it was surprising to find that Mr. Tonge imagined that his particular system enabled him to evade those reactions. He (Mr. Halbaum) was inclined to think that the system at Hulton colliery accentuated the severity of such reactions, although he did not intend to argue that point.

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fans were at work. For example, if the fan in the A mine acted alone whilst those in the B and C mines stood still, the flow of air produced by the A fan would take the course indicated by the arrows in Fig. 1 (Plate XI.). If the B fan acted alone, whilst the A and C fans stood still, the situation would be that delineated in Fig. 2 (Plate XI.); and if the C fan were to run alone, whilst the A and B fans stood still, the air-currents would flow as shown in Fig. 3 (Plate XI.). In each figure, the full-line arrows showed the air-currents of greater pressure. Thus each fan continually endeavoured to reverse the ventilation produced by the other two, and each was obliged to do work in simply bringing the air to rest, as it were, before it could propel its own current through its own mine in the proper direction. An increase in the speed of any one fan would increase the water-gauge and volume of air produced by that fan; and the other two fans would have to increase their speeds and their already inflated water-gauges simply to maintain their volumes at the same values as those obtained before the speed of the first fan was augmented.

It was thus quite clear that, whether a surface fan or a number of underground fans were employed, the ventilation of each seam would react against the ventilation of the others. Hence, to speak of the convenience of regulating the supply of air in one seam without affecting any other was to speak of a myth and an impossibility.

Mr. Tonge stated that a surface fan was obliged to run "at a speed, suitable for the one mine of the three which has the heaviest drag,"* and claimed that the employment of underground fans avoided or evaded that condition. It would, however, be noted that all of Mr. Tonge's fans were of similar make, namely, the Sirocco make; and it might, therefore, be reasonably inferred that all would have approximately the same manometrical efficiency. It might from that be again inferred that the fan on the A mine, having to produce only $\frac{7}{8}$ inch of water-gauge, would not need to run at so great a tangential velocity as the fan on the C mine, where the required water-gauge was $1\frac{3}{8}$ inches; and still less would it need to have such a tangential speed as that of the fan on the B mine, where the water-gauge required was $1\frac{5}{8}$ inches. The facts of Mr. Tonge's practice, however, as

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 210.

compared with this deduction from his theory, proved that the three fans ran at practically the same tangential velocity; in other words, they all encountered the same resistance, namely the resistance of the mine of maximum drag. The tangential velocities of the three fans (calculated from the results recorded in Table I.*) were as follows:—A seam fan, 75·9 feet per second; B seam fan, 76·6 feet per second; C seam fan, 75·0 feet per second; the mean velocity of the three fans, 75·8 feet per second; and the maximum and minimum speeds differed from the mean by 1 per cent. According to Mr. D. Murgue's tables, the theoretical depression due to this mean speed was 2·57 inches of water-gauge. The fan on the A mine exceeded the mean speed, and the normal water-gauge of that mine, according to Mr. Tonge, was $\frac{7}{8}$ inch. How did Mr. Tonge account for the balance? What did he mean by the "normal" water-gauge of the mine? What did he mean by speaking of his three fans "each running at the nearest speed to the mine-requirements,"† when all three fans were running practically at the same speed? For the tangential speed was the only speed that correlated with water-gauge. What, again, was the use of a smaller visible water-gauge, unless it was associated with a lessened tangential velocity? And where was the economic difference between destroying the surplus water-gauge at a regulator in the mine, and destroying the same surplus at an unduly contracted orifice of passage in the fan? And finally, with regard to shock, would Mr. Tonge state what, in his opinion, was the normal or radial acceleration in feet per

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aggerated notions as to the amount of pressure-difference existing between the upcast and downcast shafts. In the case of a surface fan this might be very considerable, for it amounted to practically the whole water-gauge of the fan; and any leakage through old mines or other mouthings might amount to a very serious loss. With underground fans, the pressure-difference was very small, and remained constant, in a portion of the water-gauge on the various mines, so long as the quantity of air passing up or down the shafts remained constant; and, further, as the water-gauge increased, due to the extension of the mine or reduction in the size of the airways, the proportion of the shaft-resistance was reduced. One observed fact might be mentioned, to show how small the shaft-resistance, or the difference of shaft-pressure, actually was. When the three fans described in his (Mr. Tonge's) paper were fully at work, any roadway directly connecting the two shafts in other seams was approximately in a state of balance, and the air-currents alternated in direction with changes of atmospheric temperature. The actual water-gauge readings taken at the three fans upon the quantities of air referred to in the paper, confirming this statement, were recorded in Table I.; and on a mine water-gauge of 5 inches the shaft-friction would be 2, 2 and 3 per cent. respectively. Included in the so-called shaft water-gauge was also the water-gauge due to the resistance of the air-way from the fan to the upcast-shaft, so that, as proved by experiment, the two shafts were almost of equal pressure, more influenced by temperature than by frictional resistance, and for all practical purposes might be taken as reservoirs of air.

TABLE I.—RATIOS OF MINE AND SHAFT WATER-GAUGES.

Name of Mine.	Water-gauges. Mine. Inches.	Water-gauges. Shaft and Outlet Airways. Inches.	Per cent.
A	$\frac{7}{8}$	0·10	11·4
B	$1\frac{5}{8}$	0·10	6·1
C	$1\frac{3}{8}$	0·15	10·9

Mr. Halbaum's assumption that 50 per cent. or more of the fan water-gauge was due to shaft-resistance was thus very much beside the question in this particular instance, and in all cases where the conditions were suitable for the use of underground fans. If it were possible to have so large a proportion as 50 per cent., it must almost of necessity occur in the case of a mine having low

water-gauges, with short and proportionately large air-ways and considerable air-currents, and with restricted area in the shafts. The latter conditions were named in his (Mr. Tonge's) paper as being suited to the use of surface fans. It was this abnormal shaft-resistance that caused Mr. Halbaum to foresee such catastrophes by the leaving open of the separation-doors; for, where the shaft-resistance was so small, the amount of air passing through the open doors depended rather upon the position of the fan relative to the upcast-shaft than upon any other cause. In no case, in the mines in question, did the whole of the air return back through the separation-doors when open. In one case, the air actually passed from the downcast to the upcast, and not *vice versa* as prophesied. Any accidental leaving open of the separation-doors would thus be less dangerous than if a surface fan were the ventilator, for the air in the latter case would pass straight from the downcast- to the upcast-shaft, leaving the workings untouched; while, in the assumed case of an explosion knocking down the doors, and the underground fan continuing to run, fresh air would still be delivered into the workings. He might point out, however, that any assumption of the separation-doors being blown down without damage to the other parts of the mine drew upon one's imagination very far, for a simultaneous action would take place on the fan air-lock doors and casing, which were equally open to the haulage-road, and were specially arranged so as to give way under such circumstances. This would have the effect of short-

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had assumed that many of these things had been discussed and arranged for, rather than deal with them in the somewhat hypercritical manner which he seemed to have preferred, as the arrangements for putting in underground fans were not necessarily similar to those of surface fans, but this surely went without saying.

A fan must be capable of doing the maximum duty required during the lifetime of the mine; and it usually corresponded to the highest water-gauge, and, therefore, to the highest speed at which the fan would have to run. A fan would give its maximum efficiency for a certain quantity, speed and water-gauge, and for these only. Any variation in any of these three quantities implied a lowered efficiency. The fan should therefore be designed to give its maximum efficiency at somewhere about the middle of the life of the mine. At any other than the best speed, there was one particular quantity and water-gauge, that is, one particular orifice, which gave the best efficiency for that speed. The speed at which the fan had actually to be run was that at which it would drive the required volume of air through the mine. As a rule, it was probable that the mine-orifice did not coincide with that which gave the best efficiency at this speed, but probably corresponded to a much lower efficiency.

In the early days of the mine, therefore, not only was the efficiency low, owing to the lower speed at which it was necessary to run; but, unless the mine-orifice happened to agree with the most efficient orifice for that speed, the actual efficiency would be less than the best that could be obtained at that low speed. This accounted for the somewhat low fan-efficiency obtained at present in this the third year of the working of the underground fans at Hulton collieries.

The requirements of each mine had first of all to be tested, it was found that the A mine had a lower resistance than the B and C mines, and a note in his paper was made of the fact that it was intended to change the motor (and consequently the speed of the fan).*

Mr. Halbaum did not appear to grasp the point that each mine was developing, and therefore continually requiring a higher water-gauge. This was met by increasing the size of the motor-pulley, and, consequently, the speed of the fan, or by

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 208.

reducing the artificial resistance: the former affording a coarse, and the latter a fine, adjustment. He did not claim to have abolished regulators as stated; but, as he had pointed out, the amount of pressure dropped in these resistances was small compared with what would be necessary in the case of a single surface fan. Already in the case of the B fan, the development of the mine had required an increase in the fan-speed, and the pulley had been changed. Mr. Halbaum's remarks on tangential velocity savoured somewhat of hair-splitting, and were more a matter of fan-design. Practical experience proved that the characteristic of a fan, when working at a duty much below that for which it was designed, differed very greatly from the theoretical characteristic, and was different for different fans. Mr. Halbaum had, moreover, taken no account of the blade-angles, which considerably affected the relation between the speed and the water-gauge.

He thought that Mr. Halbaum would now be prepared to admit that, where the shaft-resistance was so low, the stopping of one or more fans did not affect the other fan or fans to any appreciable extent. It was found by experience that the air-currents through the standing fans were very small, and their direction was chiefly determined by the temperature of the two shafts, varying between day and night.

Mr. Halbaum had referred to the reaction of one fan upon another, as though it was something beyond that due to shaft-friction, whereas there was no other possible cause, and this had

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THE BOULTHAM WELL AT LINCOLN.

By WILLIAM McKAY.

Introduction.—The city of Lincoln and suburbs were practically dependent for the supply of water upon the river Witham, which was contaminated by the sewerage from the farms, hamlets and towns near its banks, right away from its source. The City Council decided to bore for a fresh supply of pure water, and directed the Waterworks Committee to secure tenders for the boring of a deep bore-hole to supply at least 1,000,000 gallons of water per day.

The contract for boring was let, and operations were commenced in October, 1901. A bed of running sand having been found near the surface, metal tubbing, 12 feet in inside diameter, was constructed upon the ground in segments bolted together in the usual way, the joints being made with sheet-lead. The tubbing was placed in position, and pressed down by weights, and the sand and other material was taken out of the inside. The segments of the cast-iron tubbing were 5 feet long, 5 feet wide, and $1\frac{3}{8}$ inches thick, with stiffening ribs across the centre, and all the flanges were bracketed between the bolt-holes. The flanges were $1\frac{3}{8}$ inches thick, and the brackets and ribs 1 inch thick. The bolts, $1\frac{1}{2}$ inches in diameter, were spaced 9 inches apart. This process was continued until a depth of $27\frac{1}{2}$ feet of tubbing was put down: about $5\frac{1}{2}$ feet of the tubbing being pressed into the underlying clay of the Lias formation, so as to keep back the surface-water.

Erection of Machinery.—Long pitchpine baulks were placed across the tubbing from north to south, upon which cross baulks were placed, serving as pillars upon which other long baulks were placed to support the engine-bed, engine, head-gear, etc. The machinery consisted of a high-pressure horizontal engine, with two cylinders, each 10 inches in diameter, with com-

pound gearing, fitted with a drum for a flat-rope for winding purposes, a vertical cylinder in which a piston was placed to work the boring tool, a back-screw to clamp the rope (and to give slack rope when boring operations were proceeding), a vertical multitubular boiler to work at 100 pounds pressure, etc. There were two pulleys: one fixed on the top of the vertical cylinder; and the other served as a guide, at the back of the head-gear, in a position between the drum and the main pulley.

Boring and Tubing.—Actual boring operations commenced in March, 1902. The boring tool consisted of a long bar, about 4½ inches in diameter, with a steel block at the bottom end, a bow and ratchet at the top end and two guards, one fixed on the bar a little above the block, and the other fixed immediately below the bow and the ratchet. The cutters and shells were made secure to the block with washers and nuts. When boring, the horizontal winding-engine and the drum were at rest, the back screw having been screwed up, and the rope was clamped so that it could not move from that point on the drum. The vertical cylinder then did the actual work of boring: the piston working inside this cylinder pushed up the pulley over which the rope was conveyed, and raised the tool attached thereto a distance of about 3 feet. The tool was dropped automatically, and the cutters, striking on the bottom [redacted]

was placed in position. The lowest tube was fitted with a shoe which rested on the bottom.

After putting in this length of tubes, the size of the bore-hole was reduced, and a new block and guards were introduced to suit the reduced diameter of the hole. After this change had been made, boring was continued for a further depth of 200 feet, until the sides again became troublesome, and 200 feet of additional tubes, 26 inches in diameter, were placed in position. A further reduced hole was bored for another depth of 100 feet, and it was lined with tubes 24 inches in diameter.

The boring was continued of reduced diameter until a depth of about 885 feet was reached; but the sides of the hole then gave way whilst boring was in progress, fell down on to the top of the tool, and jammed it fast. Whilst the borer was trying to liberate the tool, the rope broke, and the tool was lost for the time being. It was then decided to sink the well in order to recover the tool, and to proceed to a further depth with the boring apparatus.

Sinking.—In 1904, the writer expressed the opinion that the 700 feet of tubes could be got out, the tool recovered, and the sinking continued to a depth of 900 feet within twelve months, and this work was accomplished within the time specified. After making the top of the shaft secure, rails were laid on the baulks so that the carriage for the hoppets might run over the mouth of the shaft.

The sinking of the shaft was commenced in April, 1904, every care having been taken not to disturb the tubbing, because of the danger of letting in the surface-water. To ensure this end, hangers (Fig. 1, Plate XII.) made of iron bars, 3½ feet long, 2½ inches wide and ½ inch thick, and twisted at the top end, were bolted to the bottom flange of the tubbing. On the hangers was placed a skeleton-ring (Fig. 4, Plate XII.) made of iron bars, 2½ inches wide and ⅝ inch thick, composed of segments made to templet, with two holes on either end. One end of each segment was cranked, so that when bolted together the ends overlapped each other. Boards, 6 feet long, 9 inches wide, and 1 inch thick, were placed at the back of the ring, and wedged tight so as to keep the sides secure, and to prevent any subsidence below the metal tubbing. A skeleton-ring was placed every

5 feet in depth, the length of the hangers (Fig. 2, Plate XII.), and boarded behind. Each length of boards overlapped the other by about 1 foot (Fig. 8, Plate XII.).

Sinking had not proceeded very far before a cavity was found, which had been caused by the sides having given way during the previous boring operations. This cavity was filled before proceeding further with the sinking.

When the sinking had reached a depth of 37 feet below the bottom of the tubbing, a double bricking-ring was put in, formed by placing one ring, 9 inches wide and 8 inches thick, inside another, and bolting them together with pieces of plank, 21 inches long, 9 inches wide and 3 inches thick, reaching from the front to the back of each segment (Figs. 5 and 6, Plate XII.), and the brick-work lining of the shaft was built upon it. All the bricking in this length was solid work, four courses of stretchers, and one course of headers or binders laid with mortar, composed of 1 part of Portland cement to 3 parts by measure of fine riddled Trent sand (Fig. 8, Plate XII.). When bricking, all the boards, skeleton-rings and hangers were taken out, one length at a time, so as to allow the bricking to be built solid into the sides, in order to make it doubly sure that no surface-water could get down at the back of the brick-work. The top part of this length was done in quarters. Wooden segments were placed at intervals below the metal tubbing, and built in solid, so that the tubbing was efficiently supported.

[redacted]

In the sinking of this shaft, several hard beds were passed through, some of which were almost entirely composed of ammonites and other shells, which in many cases could not be drilled by ratchet-machines, and hand-drilling was adopted.

When the sinking had reached a depth of 400 feet 11 inches, the shaft was reduced in inner diameter from 12 feet to 9 feet (Fig. 9, Plate XII.). The sinking of this well was somewhat more difficult than an ordinary shaft, on account of the tubes, 30 inches in diameter, being inserted down to the 400 feet level, and these had to be taken out one at a time as they were freed. Below the depth of 400 feet, the tubes, 26 and 24 inches in diameter, were removed in the same way. This process continued until the sinking reached a depth of 700 feet, and the last of the tubes had been removed. At this point another difficulty presented itself, as the bore-hole, open for nearly 200 feet below, had to be filled up. The sinking was then continued until the lost tool was recovered at a depth of 885 feet, and further until a depth of 891 feet 7 inches was reached. At this point a bricking-ring was put in, and the length bricked up; and as this was supposed to be the last length of bricking, bearer-holes were made in the upper part of it to carry a scaffold.

Boring.—About 9 feet of sinking was done below the last ring, and the bottom was levelled. A guide-pipe, 6 feet long and 3 feet in diameter, was put down and enclosed in concrete, so as to keep it in position. Another pipe, of the same dimensions, was bolted on the top of the other, and enclosed in concrete to within 1 foot of the top of the guide-pipe. Besides keeping the guide-pipes in position, this concrete made a good well-bottom, being composed of 1 part of Portland cement mixed with 5 parts by volume of broken bricks, mixed with sand and gravel. Two steel girders were placed in the bearer-holes and made fast, two other girders were placed across the fixed girders with a wooden roller on each, and when the boring was proceeding, the loose girders were placed close to the rope, one at each side, and bolted to the fixed girders, so as to serve as a stay and to keep the rope more rigid when moving up and down. Boring had not proceeded far, on account of the marl being softened by contact with water, before the sides gave way to such an extent that the tool worked at a higher level at the end of the day than

at the beginning. The bore-hole was then emptied of water and loose marl. Two skeleton-rings were inserted and boarded up, and concrete was filled in behind the boards so as to support the sides. The sides were maintained by this method, but progress was slow. After passing through two hard blue bands and a rock-bed, a little water was again tried, and the sides soon became again troublesome. The bore-hole had to be cleaned out by the use of buckets, and another ring inserted, boarded, and concreted, so as to support the sides. Boring was then resumed and continued, almost without water, until the sides gave way, and then tubes, 30 inches in diameter, were inserted. Boring was again resumed, but did not continue long on account of the red marl not being strong enough to stand, when in water. It was then decided to abandon the boring, and to recommence sinking operations until near the New Red Sandstone.

The tubes, concrete and guide-pipe were taken out, and sinking operations recommenced in June, 1905, and continued until a depth of 1,502 feet 3 inches had been reached. During the sinking of the last 150 feet, a pilot-hole was kept in advance, so as to prevent any unforeseen inrush of water. After bricking up the last length, the pilot-hole, 3 inches in diameter, was continued to a depth of 59 feet 3 inches below the last ring, and water was tapped on March 21st, 1906, at a depth of 1,561 feet 6 inches. The last 3 inches was bored in New Red Sandstone (Table I.).

TABLE I.—DIMENSIONS AND DEPTHS OF SHAFTS AND BOREHOLE.

[redacted]

Bricking.—The lower 5 or 6 feet of every length of brick-work was built in solid, so as to make each length self-supporting, even if the bricking ring should happen to give way.

Ventilation.—The shaft was ventilated by a small fan that forced fresh air through circular air-pipes, each 12 inches in diameter and 6 feet long. Bearers and pudlocks were inserted at certain distances, and the air-pipes were clamped to every bearer so as to prevent them from falling down, if the bolt should break. The shaft served as the return airway.

Strata.—The strata sunk through comprized Liassic clays, marls and shales; Upper, Middle and Lower Rhaetic marls and shales; and Keuper marls (Table II.).

TABLE. II.—SECTION OF STRATA SUNK THROUGH IN THE SINKING AND BORING OF BOULTHAM WELL, NEAR LINCOLN.

Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins
Soil	4	0	4	0
Sand and gravel	18	0	22	0
Lias	618	11	640	11
Upper Rhaetic...	16	0	656	11
Middle Rhaetic	18	2	675	1
Lower Rhaetic...	17	10	692	11
Keuper Marls	868	4	1,561	3
New Red Sandstone	0	3	1,561	6

The Lias formation contains many fossils of various species, such as ammonites, belemnites, gryphites, and other shells. The upper portion of the sinking is in Lias, to a depth of 640 feet 11 inches, the bottom being about 620 feet below the sea-level.

The Upper Rhaetic beds of dark red marl, 16 feet thick, lie immediately between the Lias and the Middle Rhaetic beds of dark shale, 18 feet 2 inches thick, containing a large number of fossils, pyritized imprints of shells and ammonites. When sinking through these strata, many loud "groumps" were heard; and, in fact, they were constantly on the move, when exposed to air. The Lower Rhaetic beds, of strong grey marl or shale and rock-band, are 17 feet 10 inches thick.

The Keuper marls, underlying immediately the Lower Rhaetic beds, comprize red marls interbanded with gypsum beds, green and blue bands, rock-beds and bands, gypsum-nodule beds

and thin layers of gypsum. In sinking through this series, the only fossil found appeared to be a detached portion of a plant-stem or branch (*Voltzia*). The sinking of this shaft was completed without any serious accident.

Water-supply.—The flow of water from the pilot-hole, after the lead plug had been put down, was at the rate of nearly 9,600 gallons per day of 24 hours. After the bottom of the shaft had been closed with cement-concrete, and the guide-pipe fixed, the water percolated through the concrete at the rate of 3,600 gallons per day of 24 hours. A boring, with a hole 33 inches in diameter, was made from the bottom of the shaft at a depth of 1,502 feet 3 inches, until on approaching the New Red Sandstone, the water broke through and lifted the tool several feet, although its weight was about 2½ tons, showing that the pressure was very great. The breaking in of the water was heard at the surface, like the rolling of thunder, and the water rose in the shaft to a height of 180 feet in 15 minutes: consequently the flow must have been at the rate of 6,868,800 gallons per day of 24 hours. The water rose rapidly up the shaft to the surface-level in less than 24 hours, and continued to run away at the surface at the rate of 8,000 gallons per hour.

The boring operations are still proceeding.

The Retiring President (Mr. Henry Bramall) moved a [redacted]

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE PHILOSOPHICAL HALL, PARK ROW, LEEDS, NOVEMBER 6TH, 1906.

MR. J. R. ROBINSON WILSON, PRESIDENT, IN THE CHAIR.

The minutes of the Annual General Meeting were read and confirmed.

The following gentlemen were elected, having previously been nominated—

MEMBERS—

Mr. CHRISTOPHER WILLIAM TAYLOR FINCKEN, Assistant Undermanager, Bramley, near Rotherham.

Mr. EDWARD LLOYD, Civil Engineer, 38, Southgrove Road, Sheffield.

Mr. CHARLES AUGUSTUS MIDGLEY, Electrical Engineer, Standard Buildings, Leeds.

Mr. PERCY MUSCHAMP, Mining Engineer, Spitsbergen Coal and Trading Company, Corn Exchange, Sheffield.

Mr. HERBERT PEAKE, Managing Director of Strafford Collieries, Bawtry Hall, Yorkshire.

Mr. JAMES RICHARDSON, Mechanical Engineer, St. John's Colliery, Normanton.

Mr. ROLAND D. SHEARD, Engineer, Messrs. Spurr, Inman & Company, Limited, Wakefield.

Mr. CHARLES STRAW, Colliery Manager, Emley Moor Collieries, near Wakefield.

Mr. GEORGE EDWARD STRINGER, Mining Engineer and Colliery Manager, Park Mill Collieries, Clayton West, Huddersfield.

ASSOCIATE MEMBERS—

The Hon. EDWARD WOOD, Garrowby, Bishop Wilton, York.

Mr. NORMAN SAVILE WALKER, 2, Dale View, Conisbro', near Rotherham.

STUDENT—

Mr. JOHN F. MIDDLEBROOK, Mining Student, 11, Hereford Road, Harrogate.

SUBSCRIBING FIRMS—

Messrs. H. BRIGGS, SONS & COMPANY, LIMITED, Whitwood Collieries, Normanton.

Messrs. NEWTON, CHAMBERS & COMPANY, LIMITED, Thorncliffe Collieries, near Sheffield.

Messrs. SKINNER & HOLFORD, LIMITED, Waleswood Collieries, near Sheffield.

DISCUSSION OF MR. T. BEACH'S PAPER ON "'BLACK ENDS': THEIR CAUSE, COST AND CURE."*

Mr. W. McD. Mackey asked whether Mr. Beach could give information with regard to the amount of gas used, and how long the doors would last.

Mr. T. Beach said that, when he had the privilege of bringing the flued door before the members, it was to some extent in an experimental stage, and he now offered further particulars as to what had since been done. The flued doors, which had been used experimentally since August, 1905, were still in use. They had never been repaired, and, to all intents and purposes, were still in a good and sound condition, and would probably last a good deal longer. At the present time, 78 flued doors were in use out of a total of 90, and they quite fulfilled his anticipations in respect to the complete prevention of the formation of seconds coke and waste of slack at the oven-ends. Regarding the economies effected by the door, he had taken a few figures from the colliery-books, and, in giving them, he desired to acknowledge the consideration that he had received from his firm in being allowed to publish them. Table I. shows that the actual quantity

Table I.—Comparative Statement of Seconds Coke made at Snydale Coke-ovens in 1905 and 1906.

Week ending	Seconds Coke. Tons.	Seconds Coke. cwts.	Week ending	Seconds Coke. Tons.	Seconds Coke. cwts.	Number of Flued Doors in Use.
1905, Sept. 6	24	9	1906, Sept. 5	5	12	52

[redacted]

completed. Assuming coke to be worth 12s. per ton, the difference in value between seconds and best coke at 5s. per ton, and bye-products at 3s. 3d. per ton of coal put into the ovens, the value of the saving effected might be taken as shewn in Table II.

It had been found essential to set the flued blocks in a stiff, rigid and strongly constructed door-frame. The light steel door was unsuitable, as it allowed the blocks to expand and

TABLE II.—VALUE OF SAVINGS PER WEEK AT COKE-OVENS.

	£	s.	d.
6·56 tons* of unburnt slack, yielding 70 per cent. of coke, 4·59 tons at 12s.	2	15	0
21 tons of seconds coke, converted into best coke at 5s. per ton	5	5	0
Bye-products on 6·56 tons at 3s. 3d. per ton	1	1	3
Total saving per week	£9	1	3

* The tonnage of unburnt slack is estimated from the average waste per charge, which was experimentally determined to be 70 pounds per charge, the number of charges per week being 210.

crack when some of the crude gas from the oven escaped into the flue. He (Mr. Beach) was unable to give the exact number of cubic feet of gas used to heat the doors; but, whatever it might be, it had no appreciable effect upon the volume of gas returned to the ovens from the recovery-plant. There had always been sufficient surplus gas, after feeding the ovens and doors, to supply two gas-engines for driving the recovery-plant, exhausters, pumps, etc.; and another gas-engine for electric lighting, etc., was now on the works ready for installation.

The PRESIDENT (Mr. J. R. R. Wilson) delivered the following address:—

PRESIDENTIAL ADDRESS.

By J. R. R. WILSON.

In addressing you as President of this Institute, I would at once acknowledge the great honour that you have conferred upon me, and confess that I may come far short of your opinions of what the occupant of this chair should be able to perform. Of all the great names which have gone before me, I yield to none at all events in the desire to do you service.

You may very naturally expect me to treat you to copious statistics showing how mining in this country, especially in regard to safety, has improved. This has been done so frequently and so well by others, that I wish to avoid it as far as possible, and I propose to glance through mining history from early times, and then to offer a few suggestions as to what the future may have in store.

I will preface my remarks with a new feature in presidential addresses, by quoting part of an eighteenth century sermon:—

Every science is the foundation of some art beneficial to men, and while the study of it leads us to see the beneficence of the Laws of Nature, it calls upon us also to follow the great end of the Father of Nature in their employment and application. I need not say my brethren what a field is thus opened to the benevolence of knowledge: I need not tell you, that in every department of learning there is good to be done to mankind: I need not remind you, that [redacted]

Cannot mining engineers rightfully claim by some of their labours and research, that they also have described wiser methods of preventing poverty, and suggested additional means of increasing the beneficial productions of nature?

John Whitaker* mentions a grant of lands made by the Abbey of Peterborough, dated 853, which seems to prove that coal was known and used in Saxon times. By this grant, certain payments in kind were reserved to the monastery, as one night's entertainment: "Ten vessels of Welch ale, ... two casks of common ale, sixty cart-loads of wood, and twelve of . fossil or pit-coal."

The first Act of the Scotch Parliament relating to mines is dated May 26th, 1424, and applies to gold and silver, ordaining that if "thre halfpennys of siluer may be fynit out of the punde of leide The lordis of parliament consentis that sik myne be the kingis as is vsuale in vthir realmys."†

Yorkshire seems to have been a very early coal-producer. In 1308, a licence was granted by the lord of the manor to dig for coals in the greaveship of Hipperholme; and in 1515, in records of the court leets connected with the manor of Wakefield, coal is mentioned as being wrought at Flockton.

In 1590, John Thornborough, Dean of York, took out a patent "to purify pit-coal and free it from its offensive smell": doubtless, one of the early attempts to manufacture coke.

It also smelt in the mine, for Dr. Kaye, or Keys, writing in 1555, mentions, probably for the first time, the appearance of noxious gases in mines:—

> We also have in the northern parts of Britain certain coalpits, the unwholesome vapour whereof is so pernicious to the hired labourers, that it would immediately destroy them, if they did not get out of the way as soon as the flame of their lamps becomes blue, and is consumed. These mines are of a bituminous nature: and the proof of the presence of bitumen, is a certain stone, black, hard, scaly, and bituminous, which we thence derive for the service and fuel of our fires. Pliny calls it Obsidian; we term it Sea-coal, or Newcastle, or Smithy coal, names borrowed either from the mode of its carriage, from the situation in which it is found, or from the use to which it is applied: for it is dug up in places near to New Castle, a famous city of England; it is carried thence by ships to the other parts of the kingdom; and it is used by smiths to soften their iron.‡

* *The History of Manchester*, 1771, vol. i., page 304.

† *Acts of the Parliaments of Scotland* (record edition), vol. ii., page 5, c. 13.

‡ *Joannis Caii Britanni de Ephemera, Liber unus, non ante æditus*, 1556, page 143; and *A History of Shrewsbury*, by Messrs. H. Owen and J. B. Blakeway, 1825, vol. i., page 346.

The position of those employed in mines was, no doubt, originally that of slavery. Though serfdom died out in Scotland in the fourteenth century, the last claims proved being in 1364, compulsory service was known long afterwards. Vagrants and sturdy beggars were obliged to find a master, or be liable to pains and penalties. In 1606, it was enacted by the Scottish Parliament that no person should fee or engage any colliers, coal-bearers, or salters, without a testimonial from their last master, showing a reasonable cause for their removal; and if anyone engaged them without such certificate, the master from whom they had deserted could claim them within a year and a day, and they had to be given back within 24 hours, under pain of a fine of £100 Scots. The deserters were also to be punished. By the same Act, commission was given to the owners of coal-heughs and salt-pans to apprehend and put to labour all vagabonds and sturdy beggars.* I am inclined to think that this Act has been repealed.

About the same time, an Act was passed in Scotland confirming former Acts against the export of coal as " the haill coill within this kingdome sall in a verie schorte tyme be waisted and consumed "; † and in 1625 it was proposed to impose a duty of 48 shillings Scots on every ton of coal exported in strange ships.‡ This proposal was rigorously opposed by the coal-owners, who urged that unless foreign vessels were employed, as there was not enough shipping in the country to transport nearly all the coal worked, the coal-trade would be ruined, the pits stopped, and many hundreds

[redacted]

estates. . . . Some south gentlemen hath, upon great hope of benefit, come into this countrey to hazard their monies in coale-pits. Master Beamont, a gentleman of great ingenuity and rare parts, adventured into our mines with his £30,000; who brought with him many rare engines, not known then in these parts; as the art to boore with iron rodds to try the deepnesse and thicknesse of the coale; rare engines to draw water out of the pits; waggons with one horse to carry down coales from the pits, to the stathes, to the river, etc. Within few yeares, he consumed all his money, and rode home upon his light horse.*

A little later, about 1676, Roger North describes coal-mining in his day as follows:—

Coal lies under the stone; and they are twelve months in sinking a pit. Damps, or foul air, kill insensibly; sinking another pit, that the air may not stagnate, is an infallible remedy. They are most in very hot weather. An infallible trial is by a dog; and the candles shew it. They seem to be heavy sulphurous air not fit for breath; and I have heard some say that they would sometimes lie in the midst of a shaft, and the bottom be clear. The flame of a candle will not kindle them so soon as the snuff; but they have been kindled by the striking fire with a tool. The blast is mighty violent; but men have been saved by lying flat on their bellies.†

In 1812, an explosion occurred at Felling colliery, by which 92 lives were lost. This accident created an impression in the neighbourhood, and, together with the writings of Dr. William Reid Clanny, a local medical man, and others, it was the means of a society being formed in Sunderland for enquiring into the causes of explosions and devising means for their prevention. This society had a very important bearing upon the future of mining. At their invitation, Sir Humphrey Davy visited the North of England in the autumn of 1815, and the result of his visit was undoubtedly the invention of the safety-lamp. The society had previously issued its first report, in which it quoted from a letter written to the society by Mr. John Buddle, who was then the leading viewer in the north. His opinion as to the prevention of explosions was by efficient ventilation, which had a different meaning in those days; and he described the methods adopted. Of the steel-mill invented by Mr. Carlisle Spedding in 1760, he says:—

On approaching the firing point with steel mills, they [the sparks] grow still more luminous, and assume a kind of liquid appearance, nearly resembling

* *Chorographia: or, a Survey of Newcastle upon Tine*, by Mr. William Gray, 1649, pages 24 and 25; reprint, 1813, pages 30 and 31; and reprint, 1884, pages 84 and 86.

† *The Life of the Right Honourable Francis North, Baron of Guilford*, by The Hon. Roger North, third edition, 1819, vol. i., page 261; and *Annals of Coal Mining*, by Mr. Robert L. Galloway, 1898, vol. i., page 160.

the sparks arising under the hammer from iron at the welding heat. . . . When the inflammable gas predominates in the circulating current, the sparks from the steel mill are of a blood red colour; and as the mixture increases, the mill totally ceases to elicit sparks.*

One could imagine that statement provoking a lively discussion, had The Institution of Mining Engineers existed at that day. Explosions are recorded, however, as being due to the steel-mill.

They believed, 100 years ago, as we do now, that the greatest safeguard in working is to get rid of the gas; the means adopted, however, were somewhat different. A scientist, writing in 1816, says:—

When the gas escapes only in regular and moderate quantities, the miner may explode it as he goes on, without producing any other effect than a pleasing phosphoric phenomena in the working, or a flash like the flash of a musket. But this, after being practised for years, unfortunately strengthens the idea of security, and the mind is incapable of informing itself what hidden reservoirs may be broken into in the future progress of a mine. A fact so simple, and yet so incontrovertible as this, can but impress everyone with conviction, and produce the natural inference, that the most desirable and most valuable improvement in a colliery would be afforded by an invention to counteract this operation of nature.†

In May, 1813, Dr. William Reid Clanny exhibited a lamp and read a paper before the Royal Society on "The Means of Procuring a Steady Light in Coal-mines, without the Danger of Explosion." The lamp was also exhibited in Newcastle-upon-Tyne in October of the same year; and on another occasion several gentlemen tried the lamp in a room filled with an ex- [redacted]

George Stephenson also invented a lamp which was tested in October, 1815, in Killingworth colliery. There was no difficulty, I believe, in finding an explosive mixture; and it is reported that the light at once went out. Mr. J. H. H. Holmes, who gave much time to the question of improving the ventilation of mines, wrote as follows:—

Mr. Stephenson is an engineer employed at the Killingworth Main colliery, so that whatever from local or practical information is required for the construction of a safe lamp he was possessed of, and undoubtedly claims great merit, if the invention produced was from his own genius. As I was present at a general meeting of the Society at Newcastle, when this lamp was presented, and made some experiments myself upon it, I am enabled correctly to describe the apparatus. . . . In regard to this lantern having been tried in a mine six weeks previous to its appearance at the meeting, I must express some doubts, as it certainly did not wear the appearance of so old a practitioner; and as Mr. Stephenson appeared totally ignorant of the manner in which the air and gases operated upon the light.*

This statement does not sound very flattering to Mr. Stephenson. Sir Humphrey Davy, after experimenting with very small tubes, undoubtedly discovered the principle of the wire-gauze. Mr. J. H. H. Holmes was very jealous of Dr. Clanny's pre-eminence. He stated that:—

Dr. Clanny had experimented with a tube, having a small perforation to convey the air from a pair of double blast bellows. After this it was not difficult to find out that small air apertures would answer the same purpose: from hence the safety concentric canals, etc., follow in regular succession of ideas; and ultimately the gauze wire apertures are the extremity of refinement, upon a principle clearly originating with Dr. Clanny.†

This gentleman had made experiments with Dr. Clanny, and is very proud of the advantages to be obtained by the use of this lamp. He mentions one instance where the downcast-shaft at a colliery was under repair, and the only entrance for the horsekeeper was by the upcast-shaft, and so inbye, where "he would be compelled to pass through a region or tornado of inflammable air"; and he explains how a bore-hole had been put down from one seam to another which was worked out, in order to drain off the gas which was coming up staples and fissures in the strata; and it was this part of the mine which the horsekeeper had to pass. "When the wind is north, north-north-east or north-west," he says, "the gas is going down; but

* *A Treatise on the Coal-mines of Durham and Northumberland*, by Mr. J. H. H. Holmes, 1816, pages 187 and 188.

† *Ibid.*, page 204.

when south-east or east-by-north, the gas is given up and rushes through this aperture in the most violent manner." The lamp was used here, "and by this means the man was enabled regularly to attend to his cattle."* This enthusiast was quite aware that improvements cost money, for he says, in 1816, "I am aware that the coal-owner has at all times but a speculative property, and frequently sinks an immense capital without knowing how far the deposit of coals may answer his expectations; and sometimes, owing to the working of too great a number of pits at one time, and consequent depreciation in the market, is rendered a great loser by his trade."†

Dr. Clanny was not long in improving his lamp and adopting wire-gauze above the glass. Mr. Matthias Dunn, one of the first inspectors of mines, says, "to Dr. Clanny, beyond all doubt, belongs the honour of first conceiving the idea, and of executing a lamp to burn safely in an explosive atmosphere. . . . In the year 1815, however, the safety-lamp of Sir H. Davy was discovered; and . . . has been the means of recovering millions of value in coal, otherwise irrecoverably lost. It was on the first of January, 1816, that the lamp was first tried by me at Hebburn colliery."‡

The feeling of the coal-owners in the matter can be gauged by a speech made in September, 1817, when the colliery-proprietors of the north of England entertained Sir Humphrey Davy at dinner in Newcastle-upon-Tyne. Mr. J. G. Lambton, in presenting a service of plate, said:—

[redacted]

stances. Not a single failure has occurred—its absolute security is demonstrated. I have, indeed, deeply to lament more than one catastrophe, produced by foolhardiness and ignorance, in neglecting to use the safeguard you have supplied; but these dreadful accidents even, if possible, exalt its importance. If your fame had needed anything to make it immortal, this discovery alone would have carried it down to future ages, and connected it with benefits and blessings.*

In 1833, Mr. Carleton Tufnell, a commissioner appointed to carry out the provisions of the Factory Act, made enquiries into the condition of the miners in Lancashire. His report disclosed a state of affairs which, to-day, seems to us to be well nigh impossible. The cruelty to children, the revolting condition of women and girls, and the barbarous methods of mining generally, make one ashamed that those responsible could call themselves Englishmen. There were doubtless exaggerations made and also some misconceptions, for it is stated that after Mr. Cobbett "had been lecturing at Newcastle and adjacent towns in the autumn of 1832; in the interval of a week or two, the inhabitants of the neighbourhood were not a little surprized to read, in the *Political Register*, the following paragraph:—'Here is the most surprizing thing in the whole world; thousands of men and thousands of horses continually living underground: children born there, and who, sometimes, never see the surface at all, though they live to a considerable age.'"† For children, in this outburst, perhaps one should read horses.

In March, 1834, a petition was presented to the House of Commons on behalf of the coal-masters and miners of Staffordshire, praying for a scientific board to examine all lamps intended to be offered for sale to the public as safety-lamps to be used in collieries, and to direct the stamping of all such as they shall approve, and to prohibit the sale of any as safety-lamps, which shall not be so approved. This was really the outcome of experiments by interested persons to show how unsafe the Davy lamp might become in fire-damp. That petition had not yet been granted. Perhaps, even after this lapse of time, the present House of Commons may consider the matter.

In August, 1839, a number of South Shields gentlemen, appalled by the great loss of life in collieries, formed themselves into a committee to investigate mining accidents. They took

* *The History and Description of Fossil Fuel*, by Mr. John Holland, 1835, page 277.

† *Ibid.*, page 241.

a great mass of evidence, and made a report. They made several suggestions, amongst them being one for a proper inspection of the mines by Government officials; and they pointed out that the practice had been adopted on the Continent for a long time with the best of results.*

In 1842, the report of a Royal Commission appointed to enquire into the employment of children in mines was published; and a woeful state of affairs was revealed. Children of three or four years of age were taken into the pits. I can well remember one or two old men telling me that they were carried into one of the north country pits, when they wore petticoats, at the age of four.

Women were largely employed underground in Scotland, Lancashire, Yorkshire and South Wales. Some twenty years ago, an old underviewer remarked to me after we had visited the working place of an old collier, "Bill's a good chap, but he's not as good a man as his wife; she used to tram for me." But all colliers were not satisfied with the condition of things. It is reported that a meeting of some 300 of them was held in Barnsley, and they passed a resolution that "the employment of girls is highly injurious to their morals; that it is not proper work for females; and that it is a scandalous practice." After stormy debates in both Houses of Parliament, chiefly in the Upper one, the Royal assent was given on August 10th, 1842, to the Act which provided that no women and girls were to be employed underground, nor boys under the age of ten years;

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not so much the coal-owners as the butties, who were generally also the landlords of the adjacent public-houses; while the colliery-owners were the proprietors of the "tommy-shops." Between them the poor colliers seem to have been betwixt the upper and nether millstones, and no wonder they created disturbances and organized strikes. Their meetings, amongst other things, seem to have been productive of the formation of co-operative societies and trades unions; and in these days certainly, they were born of oppression by despotic employers against weak and ignorant workmen. In July, 1844, Mr. S. Tremenheere, the inspector who was appointed under Lord Ashley's Act to make enquiries, but not to enter the mines, made his first report after examining the Scottish coal-districts. He mentioned that the proprietors had been compelled to use ponies for haulage, instead of female labour, and that the change had actually proved economical.

At this time a meeting was held in Newcastle-upon-Tyne which resulted in a Bill getting so far as to be printed and circulated. It provided for the country being divided into districts, each under a registrar; to obtain returns from the mines; correct plans of the workings; names of owners and lessees; sections of strata; number of seams and their inclination; direction of faults, etc., and the system of working adopted. Rather a forecast of much more recent legislation.

Serious explosions were terribly frequent: the public generally were startled, and the miners in various parts of the country met from time to time, discussed the dangers of their calling, and sent petitions to Parliament.

In August, 1845, the Government appointed Sir Henry T. De la Beche and Dr. Lyon Playfair to enquire into the cause of colliery-explosions, and, if possible, to advise as to the measures for their prevention. Many of the large collieries, one ought to bear in mind, had only one shaft, divided by a wooden brattice. The commissioners travelled about and obtained information, and made their report in June, 1846. Briefly, they condemned a large number of mines, classing them as wretched, and the officials who managed them as very ignorant. They suggested "Careful and judicious inspection by competent persons," and anticipated very good results from it.

There were several explosions in different parts of the country during this year. The colliers continued to hold meetings and

send petitions to Parliament. In May, 1847, the Miners' Association of Great Britain sent a petition asking for legislation; they also asked for the appointment of inspectors to visit all the mines; and suggested that the inspectors should have very large powers. Earl Fitzwilliam brought some of these petitions before the notice of the House of Lords.

In January, 1849, an explosion occurred at Darley Main colliery, near Barnsley, by which 75 lives were lost, caused, as most of such disasters were, by the use of naked lights and great laxity in the management. The Government were again pressed to do something, and Lord Wharncliffe was successful in moving for the appointment of a select committee to enquire into this subject. The commission reported not only upon the general condition of British mines, but upon that of foreign mines also; and agreed that the latter were better, and the officials and workmen employed there superior in education to those employed in Great Britain. Evidence was given pointing out the necessity for two independent shafts, and for better systems of ventilation; and, of course, Government inspection of the mines.

In 1850, the Act was passed which first provided for Government inspectors entering any mine, as well as examining all the works and machinery upon the surface, and enquiring into all matters relating to the safety of those employed: really the first Parliamentary interference with the actual management of mines. The mines of the country were now producing some 50,000,000 tons of coal per annum, and giving employment to [redacted]

some criticism upon many of their suggestions. He points out—and how often comparisons of this nature have been made—that since the safety-lamp came into use the number of deaths by explosion had increased; and since inspectors were appointed, that the deaths had multiplied alarmingly.

The inspectors compiled a list of fatal accidents for the years 1851 and 1852, and the total was 2,040, so another select committee was appointed to make enquiries. This committee reported in June, 1854. Every side of mining was touched upon; coal-owners, viewers, workmen, and inspectors were all drawn upon for opinions. Great stress was laid upon the provision of better ventilation; and this committee reported in favour of the furnace; they also suggested some rules to be enforced by legislation. Of course, the number of inspectors was to be increased, and this time it was suggested that their salaries be augmented.

On August 14th, 1855, the Royal assent was given to an Act which embodied the principal feature of the committee's report, and provided for General Rules and Special Rules. And on August 28th, 1860, another Act was passed which increased the number of General Rules to fifteen; the age of prohibition of boys was raised, and education of some kind secured to them.

About the middle of the last century, the system of ventilation, that is, where there was any system at all, was almost entirely by furnace, usually fed by return-air. It is recorded that one of the hottest shafts at this period (1850) was at Marley Hill colliery, in Durham, where the average temperature was 168° Fahr., and at Hetton colliery it was 145° Fahr. The volume of air per minute obtained at a few of the largest collieries was as follows:—Hetton, 190,000 cubic feet; South Hetton and Murton, 132,895 cubic feet; Wallsend, 121,360 cubic feet; and Haswell, 100,000 cubic feet: this result being obtained by splitting the air-currents, a system which was now beginning ta be understood (it was introduced about 1840).

At Hetton colliery, we learn that the air was divided into sixteen different currents. Prof. J. Phillips stated that the average length of the air-courses in the larger collieries did not now amount to 3 miles. Mr. Dunn mentions in his *Historical, Geological and Descriptive View of the Coal Trade* that, at the beginning of the nineteenth century, the air-current at Hebburn

colliery traversed at least 30 miles. In Yorkshire, the introduction of large volumes of air into the mines may be said to have only commenced at the middle of the century. Until 1845, the Oaks colliery, Barnsley, then the deepest in Yorkshire (848 feet), was ventilated by means of a fire-lamp placed in a recess in the upcast-shaft—though furnaces had long been in use in other parts of the country.

About 1850, the best ventilated mines in Yorkshire were Honeywell colliery, Barnsley, with 39,666 cubic feet; Oaks colliery, 31,000 cubic feet; and Darley Main colliery, 30,000 cubic feet; and the furnaces in many cases were supplied with fresh air.

As far back as 1811, Mr. John Buddle applied a steam-jet at Hebburn colliery, as a temporary expedient for getting rid of some gas, when the furnace was considered dangerous. He placed the jet nearer the top than the bottom of the shaft.

In 1828, a steam-jet was used in a more permanent fashion at a colliery in Wales, but it was not until 1840 that the question was considered seriously. Opinions apparently differed very greatly as to the useful effect of this system. Numerous experiments were made, jets were tried at the top, part way down, and at the bottom of the shafts: with furnaces, with boilers in the pit, and without either; but generally, when any reasonable amount of air was obtained, the results could be attributed largely to the heat of the shaft. I cannot find any correct account of a steam-jet being used where the shaft was previously cold.

One of the earliest instances in which mechanical ventilation [redacted]

as being admirably adapted for the purpose for which it is intended. The construction, we understand, is of a very simple description; but such is its power and capacity, that it is calculated to extract between eight [thousand] and nine thousand gallons of gas or air per minute, which is driven at the rate of 65 miles per hour. With this apparatus in operation, the inventor expresses his fullest confidence that the pit may be entered at all times with lighted lamps, and with the most perfect safety. At the top of the shaft, a small gas-cock is fixed, by the means of which the state of any pit may be at any time ascertained with the greatest precision. The great advantage of the principle on which this apparatus is constructed is, that instead of forcing the atmospheric air into the pit, as by the old plan, it first extracts the hydrogen gas, and the atmospheric air then follows down the shaft, thereby rendering an explosion impossible.—*Leeds Times*.* By this machine the ventilation can be multiplied to an incredible extent, making the draft of air through the mines 31 times greater than at present.—*Wigan Gazette*.†

In 1837, one of these machines, 5 feet in diameter and 2 feet wide, was applied at the Osmondthorpe colliery, Leeds, to get rid of the products of a fire, which had originated from an explosion. Mr. Fourness was really the first in this country to make mechanical ventilation an actual success.

In 1842, Mr. Benjamin Biram, viewer at Earl Fitzwilliam's collieries, patented several rotary machines on the screw principle. In the same year, he applied a fan at Elsecar colliery. It was placed at the bottom of the shaft, and driven by a jet of water impinging upon small buckets on its periphery. It was used a few years and then replaced by a horizontal fan at the surface. A few years later, this gave place to another Biram fan, 23 feet in diameter and 4½ feet wide, with a single inlet; this fan is still at work and exhausting a large quantity of air. In 1841, we first hear of the water-gauge, and a few years later its use became common in the mines. And now great interest was taken in the question of ventilation, as the *Proceedings* of the Institution of Civil Engineers and the *Mining Journal* of that period show; and the various controversies were of great benefit to the mining community.

In Yorkshire, we are familiar with the fact that it was in 1811 that John Blenkinsop, of Middleton collieries, Leeds, took out a patent and ran a locomotive engine from the colliery to the town --using toothed wheels and rails. Two years later, William Hedley, of Wylam colliery, after many experiments, took out

* *The Mining Journal*, 1837, vol. iv., page 71.

† *Ibid.*, 1837, vol. iv., page 166.

a patent for a locomotive which would draw a train of loaded wagons by the friction of the wheels upon the rails. Speaking of a second engine, constructed with two cylinders, Mr. Matthias Dunn says, "This engine succeeded so well that it drew eight loaded waggons at the rate of 4 or 5 miles per hour, and completely superseded the use of horses, which at that time was a ruinous expense to the colliery. . . . . . In justice, therefore, to Mr. [William] Hedley, he is entitled to the honour of being the inventor of the present principle of locomotion."* In 1814, George Stephenson fitted up an engine at Killingworth colliery, the motion of which was communicated to the wheels of the engine-carriage by means of an endless chain instead of cog-wheels; and its action depended upon the friction of the wheels upon the rails. Every schoolboy has learned what an influence this invention had upon the trade of the country, and the coal-trade in particular.

Wire-ropes appear to have been first used in mines in the Harz mountains, in 1834, and two or three years later they were introduced to the notice of British coal-owners. Mr. M. Dunn seems to have been a pioneer in this as in many other matters, and used the first iron-wire winding-rope for a staple pit in St. Lawrence colliery, Newcastle-upon-Tyne, in 1840.†

About 1830, conductors of wood were patented by Mr. John Curr, who had charge of the Duke of Norfolk's collieries, at Sheffield. They soon became common in the Leeds and Barnsley districts also, as well as conductors of iron-rods. Mr. Curr

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time the winding-engine had been a combination of a drum actuated by a water-wheel, which, in its turn, was supplied with water by the fire-engine. Mr. Curr, writing in 1797, estimated that there were at that date 30 or 40 of these water-wheel gins with their fire-engines in use in the north of England.

In the deep mines of the future, we may revert to a system carried out at the end of the eighteenth century. At one or two collieries in the Whitehaven district, the coal was wound in a succession of lifts. Mr. John Holland states that, "In the Alfred pit, at Jarrow, there is a 30 horse steam-engine erected at a depth of about 130 fathoms below the surface: it is used in raising the coals up a shaft which unites with the workings, carried out 45 fathoms deeper still: there is likewise at the profound depth indicated by these two shafts, another steam-engine, to draw the coals up an inclined plane that lies coincident with the dip of the strata."*

The year 1862 will always be memorable for the disaster at Hartley colliery, where the beam of the pumping-engine broke, and, falling down the pit, practically sealed up the mine. There was only one shaft here, divided by a wooden brattice, and 204 poor creatures lost their lives. Their sacrifice gained for their fellow-workmen, that same year, an Act which rendered such mantraps impossible in the future. One wonders why the division-brattice in some of these mines was not often destroyed, for one reads that streams of water were allowed to trickle down the brattice to prevent the furnace from setting fire to the timber. It is interesting to note that the first patent for mechanical coal-cutting dates from this year.

There was still much clamour for improved conditions of underground labour, and each year provided its most eloquent advocate in the way of great loss of life from explosions. More commissions were appointed and reports made. Yorkshire became very prominent with the Oaks colliery-explosion in December, 1866, when 334 men and boys, and an unusually large number of volunteer explorers lost their lives. The death-quota that year was 1,500.

The passing of the 1872 Act, introducing certificates for managers, and a good code of general rules; and the 1887 Act,

* *The History and Description of Fossil Fuel*, by Mr. John Holland, 1835, page 200.

providing that assistant or under managers shall also be certificated, brings us to fairly modern times to which further reference need not be made, excepting to make a comparison (Table I.) showing the improvement that has taken place in regard to safety, in the last 55 years.

TABLE I.—RATIO OF MORTALITY FROM DIFFERENT CAUSES OF ACCIDENTS IN AND ABOUT MINES CLASSED UNDER THE COAL-MINES REGULATION ACTS, PER 1,000 PERSONS EMPLOYED, AND PER 1,000,000 TONS OF MINERAL RAISED.

Year.	Death-rate from Accidents per 1,000 Persons Employed.							Death-rate from Accidents Underground and Above-ground per 1,000,000 Tons of Mineral raised.
	Underground.					Above-ground.	Underground and Above-ground.	
	By Explosions of Fire-damp.	By Falls of Ground.	Shaft Accidents.	Miscellaneous Accidents.	From all Causes Underground.			
1851	1·86	1·90	1·27	0·42	5·46	0·99	4·55	19·34
1872	0·40	1·37	0·40	0·65	2·96	0·89	2 53	8·59
1887	0·35	1·10	0·20	0·44	2·14	0·81	1·89	5·75
1905	0·26	0·75	0·09	0·40	1·49	0·75	1·35	4·64

And this improvement is not to be attributed entirely to legislation; it is due to the spread of knowledge: to the spirit of the times; to scientific institutes like our own; it is due to the enhanced value placed upon human life; and, now I would say, for no class of labour is there greater solicitude and care, on the part of employers and officials, than for those who

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producers and gas-engines of large power, the dynamo and electric motor, the quick-revolution engine and the water-tube boiler. Those of you who are controlling large modern mines do not need to be told of the progress that is being maintained in all departments of mining; and we all appreciate the necessity for continually taking advantage of every discovery and every practical invention.

From the trend of labour-legislation and the development of true socialistic ideals, we may look in the near future for extensive changes. The environment of a large colliery will be very much in the nature of a self-contained village. We shall see a church, free in the best sense of the word, free to radiate all the good it can, without cramping the honest aspirations and opinions of its adherents; an institute for mental and physical recreation; schools that will endeavour to teach the young how to live, as well as acquire smatterings of pseudo-science. A hospital for the relief of all connected with the mine, which will embrace a staff of nurses, who can devote some time to house-visitation, and, perhaps, instil into the wives of the workmen some of the advantages of common-sense in tending sickness. The girls will have a cookery school, so that when they come to preside over households, they will be equipped with one factor that will make for the increased worth and contentment of the men—the caring more efficiently for their bodies.

At evening classes for the boys they will be allowed the use of the colliery-shops with electrically-driven machinery, where they will probably notice that the larger fly-wheels of engines are smoothly cased at the sides to prevent loss by friction. The best boys will rise most quickly to the best-paid positions. They will discover that knowledge pays. Some of the cleverer boys, after passing certain courses of study in the local school, will be assisted to the universities: and perhaps a few also will get their articles of apprenticeship to the colliery-manager, with the addition of a small salary, so that they may not starve their bodies while they are endeavouring to enlarge their minds. A children's library will be connected with the school, and will be under the charge of the teachers, who, while having a part in the selection of the books, may also, by their influence, guide the reading of their pupils.

Perhaps one of the newest features in the surroundings will

be an isolated building, somewhat akin to an engine-house, in close proximity to the coke-ovens, and known by the name of the crematorium.

A co-operative store will continue to attract custom by the large dividends paid. The workmen's cottages must approach more nearly to those associated with the garden-city movement. They will naturally be erected so that the prevailing direction of the wind will take the little smoke that is made away from them. The houses, while preserving a certain uniformity, will vary in size, and all have gardens. Some of the larger houses will receive lodgers, and a list of them will be kept at the office of the gentleman known as the social secretary. Attempts will be made to allow workmen to become the owners of their dwellings; and these houses will be built apart from the rest, upon land kindly given by the lessor of the minerals, in order to lessen the cost and encourage thrift. These houses, of course, will be paid for through the means of increased weekly rent: one of their distinguishing features will be a good roomy general living apartment, and the elimination of the stiffly furnished and rarely used uncomfortable parlour. It will probably be a rule, in the case of coal-getters, for supplies of coal to be delivered to the houses of those who have wrought them: and one can understand that the wife of the day-wageman will always ask for the number of the "motty" or token.

The refuse will be taken away and consumed by the waste-gases from the coke-ovens, or in some other economical form of

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In the management of the concern, a committee of workmen chosen by themselves will assist the officials in settling all questions between employer and employed, and take part in controlling the organizations in the village. The manager will find it helpful to meet all his underground officials together, excepting those on duty at the time, every week, and discuss all underground questions with them. All will be invited to come with suggestions previously placed upon the agenda-paper. The workmen's committee will join them once a month: amongst other things they will settle the question of distances at which timber should be set; when the men should travel outbye by the return-air roads, etc. All workmen will be encouraged through their committee to make suggestions, and all having a monetary value to the employer will be paid for. All officials will be provided with suits of blue cloth, someone having discovered that it adds to their dignity and promotes efficiency.

Most of the higher officials in every department will be certificated men of some kind. We shall then probably revert to former methods of selecting officers, not because they have a certificate, and are cheap, but for their capacity and experience.

One of the most capable officials will be the social secretary, a man of many sides. All men applying for work must first interview him: and if the interview is satisfactory, he will pass them on to the official who may employ them. He would also under the committee have charge of the institute, and be the recognized leader in all forms of recreation, whether of a mental or a physical kind. He would look after the letting of the houses, and keep an eye on those which accommodated lodgers.

The chemist, in addition to having charge of the production of pure coke, and the production and use of gas, will also see to the quality of the water used, the purity of all oils and grease, and the general preservation of ropes and colliery-stores.

The under-manager will take care that a deputy has never more than 50 men under his supervision in an ordinary longwall-face. Coal-cutting by machinery, even in the thicker seams, where the gradient is not too excessive, will be the rule; and this will come about not for economical reasons, or because it promotes better timbering and general safety, but because the miner will decline to do this, the most arduous part of all mining operations.

The lighting of pit-bottoms and approaches, already very satisfactory in many places, will be much extended; on the principle that a man is much safer in the light, and, with the recollection that you can have a good light for 1d. an hour, whereas an idle man may cost you 9d. an hour.

It is marvellous to-day to see how the weighmen at some of the large concerns get through a big day's output. I think that they may have a somewhat easier time in the future, when they get all tubs weighed automatically: the motty number being called out, the weighman will depress a key of that number, and the exact weight and number will be recorded upon a travelling tape; the weighmen will copy the records and preserve the tape in cases of dispute.

More managers, I believe, will see the advantage of contouring the plans of the underground workings, like a surface ordnance-map. Some already have the levels carefully marked upon the plans: but the lines of equal altitude, showing the wonderful hills and dales in an apparently regular coal-field, will be of very great service in laying out any system of haulage, and of immense value in designing how an upper or lower seam should be worked.

As a knowledge of ambulance-work is even now almost essential to every man applying for a colliery-manager's certificate, we all expect to see considerable extension in this direction; no official without an ambulance-certificate will obtain employment. Rescue-stations, in groups, will be imperative within half-an-

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life at the rate of one-sixtieth of the average wages in respect of each year for which the contribution has been paid. On leaving his employment, a contributor would receive his own contribution only: a slight inducement to remain at one place. At death, the contribution with 2½ per cent. interest, together with the company's contribution, would be paid to the relatives. At death, after the pension had been received for a time, the same contribution as above, less the amount paid in pension.

One has occasionally to think out the problem of what to do in the case of a surface-fire, when the downcast shaft may be endangered. Some means of readily reversing the ventilating current will naturally be of the greatest assistance. I am indebted to Germany for the idea of a safety-shaft; at the Shamrock collieries, Westphalia, I saw an arrangement like the following:—The downcast and upcast shafts are connected together by a drift, just below the surface on the level of the fan-drift. At some point in this drift, between the two shafts, is a third or safety shaft, or rather an independent entrance to the drift. It is arranged entirely for cases of emergency, so that should, say, a fire break out about the surface of the downcast-shaft, the downcast could be quickly sealed off above the level of the drift, that is at the low landing, by a cover kept in readiness for the purpose; this cover could be in the form of a scaffold with iron leaves, or in several ways which will suggest themselves to you; then the entrance to the emergency-shaft would be opened and allow the air to travel on the drift into the downcast pit. In case of a fire in the downcast-shaft, when it might be necessary to reverse the ventilation and cause this shaft to be an upcast; the doors, A and B, in the fan-drift (Fig. 1), would be closed; and the door, C, would be opened: the top of the upcast being at the same time altered to admit the fresh air.

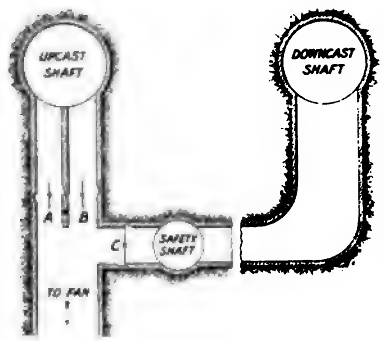

FIG. 1.—ARRANGEMENT OF A SAFETY-SHAFT.

Many minds are already at work upon that most serious problem—coal-dust. Perhaps some of our new mines will

be laid out so that the travelling roads will be the main-intake airways; the haulage-roads will also be in the intake air, but the currents will be regulated much below the speed of those in the travelling-roads: when I say travelling-roads, it does not imply that the workmen will always walk. Of dust, we may read in some new Act, "it shall not be allowed to accumulate in the roadways"; which can be met by not allowing it to go into the mine; and, by using dust-tight tubs and sprinkling the tops of full ones with water before the tubs come into contact with such a current of air as is likely to carry away the dust. The same Act may probably say that "reasonable precautions shall be taken to prevent dust caused in screening from finding its way into the mine." At some of the large mines this will be interpreted as meaning that the screens must not be erected nearer than 300 feet to the downcast-shaft.

We are continually being reminded of the destructive effects of this agency, and there is some action that as yet we little understand. The results of some dust-explosions seem in no way commensurate with our conception of their propagation. A blown-out shot may or may not originate a disaster; it would seem to depend upon the character of the wave produced; and its violence as to whether or not detonation was set up in the galleries of the mine. I am hoping that one of our professors of mining will, in the future, have something to tell us upon this abstruse subject.

To-day and to-morrow are both times of large outputs and

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adopted with considerable success. A first-class concrete (matured) will withstand a crushing strain of nearly 5,000 pounds on the square inch. It is easily applied, is about three times the strength of good brickwork of the same thickness, and makes a perfect joint with the strata irrespective of any inequalities. In the case of pressure due to a considerable head of water, the lining can be very much strengthened by a form of ferro-concrete; and a ready and effective way when the shaft needed a temporary lining, would be to leave in the skeleton-rings and hanging rods, some 2 inches from the side, and embed them in the concrete. In an actual case supplied to me from Belgium, the lining was inserted in 3 feet lengths, some 10 inches thick, and a length of 12 feet was completed within 24 hours. The advantages over brickwork were:—Less area and less quantity excavated in the shaft, and consequently greater speed; less thickness and less quantity of lining, and cheaper materials. On the whole, the balance was very much in favour of the use of concrete.

As an example: with a shaft, 20 feet in diameter, having a head of water of 100 feet, the thickness of brickwork to withstand that pressure would be 4 feet 4 inches; that of concrete 1 foot 3 inches, allowing a maximum working stress of 166 pounds per square inch for bricks and 400 pounds per square inch for concrete: and cast-iron tubbing only 1 inch (according to recognized formulæ, a thickness of 0·35 inch would suffice for a working stress of 15,000 pounds per square inch, if retention of shape and wedging and corrosion had not to be taken into account).

I think for deep pits where the run is continuous, that there will be no difficulties with rope-guides. Where intermediate landings are necessary they are distinctly objectionable: and then either wood or inverted channel-steel, or the two combined, are to be preferred. For some time I held the opinion that there was considerable risk with rope-guides, for the reason that vibrations set up by the cage might be gradually intensified until collisions occurred. After considerable observation and some experiment I have come to the conclusion that the vibration in a properly-fitted shaft is very small. Prof. G. R. Thompson, of Leeds University, and myself have made a few experiments in deep shafts with a form of pendulum suspended in the cage, free

to oscillate in every direction. At the end of the pendulum was a sliding pen which recorded upon a sheet of paper, upon the cage-decking, all the movements of the cage in ascending and descending; the results were very interesting. It perhaps does not always strike one that in a shaft, say, 2,700 feet deep, the velocity of a wave, in a rope of that length of proper strength and suitably weighted, would only be about 400 feet per second. To minimize any tendency to vibrate in unison, the guides could be weighted unequally, so that the waves in the respective ropes would not be of the same pitch. A further help to smoothness of running would be the adoption of locked-coil rope-guides. Experience would suggest having two rubbing ropes between the cages, and allowing the cages to touch them; the clearance that is required is at the corners. Ten guides in a shaft heavily weighted at the bottom cost a great deal in metal alone; it would not be at all difficult to diminish considerably the quantity of metal by attaching a lever at the end of each guide, and placing the weight upon the lever. German engineers do not agree with us in the use of rope-guides, at any rate for their conditions. Their opinion is unmistakable in the following quotation:—"As a relic of the time when English capital and English engineers had taken foothold in some of the mines of this district, we still find in Westphalia some rope-guides. Even to-day such are in use at the Zollern collieries, whilst in the Erin and Hansa collieries, this kind of conductor, so highly characteristic of English mining, had to give way to wooden

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or a water-gauge, which would at all times tell what the fans were producing.

I think that we may all anticipate further legislation affecting mining. It will be of interest to those working thick coal if, in the future, in moderately thick seams, leaving in a mine more than a certain percentage of good coal, will be punishable by a fine. We should then not have the anomaly of a thickness of coal, which in one part of a district may be considered a good workable seam, in another part being left behind in the goaf.

It would not seem unreasonable if, in unproved coal-areas, where a prospective colliery-owner has spent money in proving the minerals, he should, unless otherwise compensated, be entitled after commencing to work coal, to deduct from the rent the cost incurred in boring. And it would be of advantage to the industry if it were compulsory for royalty-owners to sell or lease their coal to the nearest mine-owner at a fair valuation. And, on the other hand, the nearest mine-owner on receiving notice from the royalty-owner should accept a lease upon equitable terms, to commence from a period when the working-faces should reasonably reach the area in question.

Speculation, however, is rather treacherous ground. Of one thing we are all convinced, that, whatever the future produces, it will require good men; men who can combine a high theoretical training with practice; and I trust and believe that the educative value of this Institute will be one of the factors in providing them.

Appendix A.—Safety-lamps.

[Fig. 2] represents the [Dr. W. R. Clanny early] lamp as it now is ready for use. *a*, The body of the lamp, constructed of copper or block tin; *b*, a conical tube which carries off the air (deprived of its oxygen by combustion) through the water in the cistern, *c*; *d* is a cistern containing water to keep the lamp cool, if necessary; *e*, the window of the lamp made of very thick glass; *f*, the candle, supported upon a tin stand; *g*, a cistern containing water through which the air is forced by the bellows; *h*, a tube from the bellows which conveys air for supporting the combustion of the candle. An elastic tube may be fixed to the valve of the bellows in case of necessity, by which to draw atmospheric air from any distance to supply the lamp.*

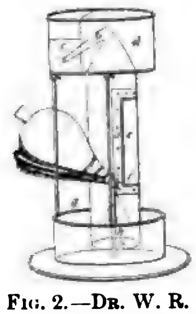


Fig. 2.—Dr. W. R. Clanny's Lamp.

* *A Treatise on the Coal-mines of Durham and Northumberland*, by Mr. J. H. H. Holmes, 1816, page 113.

[Fig. 3] represents the lamp upon Dr. Clanny's original principle in a more portable and improved shape; the strata of water being dispensed with, and the air urged in by bellows through the oil which supplies the lamp. . . . . *a*, a tube fixed to the lamp, and which conveys the air; *b*, lamp for oils; *c*, air apertures under the burner in the oil; *d*, conducting tube, to which an elastic tube, having the bellows at one end, is fixed; *e*, a pin passed through the tube to prevent the lamp from falling out; *f*, bellows; *g*, the glass.*

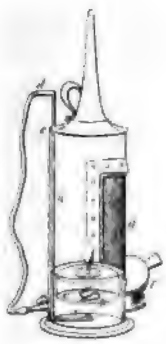


Fig. 3.—Dr. W. R. Clanny's Lamp.

[Fig. 4] represents the lamp invented by Dr. Clanny for passing the air necessary for the combustion of the candle through a cistern of steam; *a*, tube by which air is admitted; *b*, tube fitted air-tight in the smaller tube *a*, and which supports the water and steam cistern; *c*, cistern in which the water is kept boiling by the flame of the lamp; *d*, *d*, tubes, through which the air, after passing up the tube *b*, descends to supply the combustion of the lamp and then passes up the sides of the cistern out of the chimney; *e*, bottom fitted air-tight; *f*, the glass.†

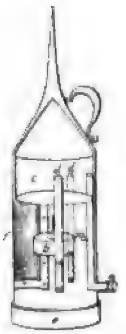
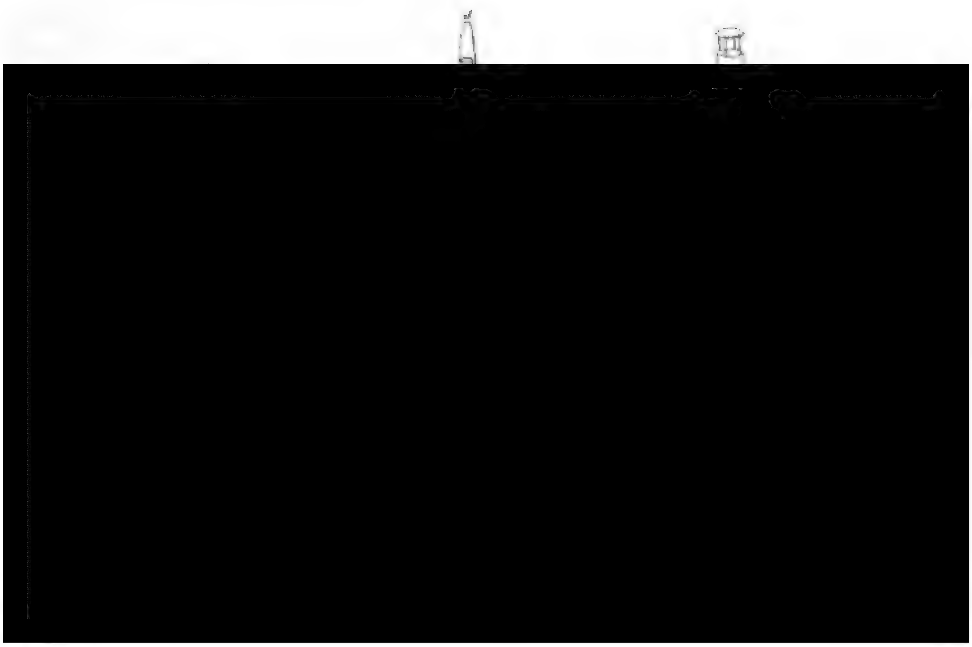


Fig. 4.—Dr. W. R. Clanny's Lamp.

[Fig. 5 represents Mr. R. W. Brandling's lamp, depending upon the idea that purer air will always be in a lower stratum.] This lamp was constructed of tin, being about 12 inches by 8 [inches] square, and was supplied with a bellows chamber at the top for the purpose of accelerating the draught of air. . . . . *a*, the bellows; *b*, the perforations for the air to pass out of the lamp, over which lies a small piece of wood hinged on with leather as a valve; *c*, the glass; *d*, the oil lamp; *e*, a belt by which the lamp is carried; *f*, the elastic tube [for taking in air].‡



[Fig. 7] represents Sir H. Davy's lamp, with the air feeder and chimney, furnished with the concentric metallic canals; . . . the sides are of horn or glass made air-tight, and at the top is a hollow cylinder covered with a cap to prevent dust from getting into the lantern.*

[Fig. 8] represents a lamp upon the same principle as [Fig. 7], with concentric metallic air feeders at the bottom, and a glass chimney with similar canals in the top, and covered with a tin plate.*

[Fig. 9,] a metallic gauze lamp, with screens of wire gauze, and so constructed that the wick may be trimmed without inconvenience.*

FIG. 8.—SIR H. DAVY'S LAMP.

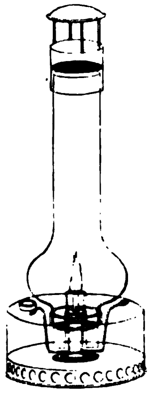


FIG. 9.—SIR H. DAVY'S LAMP.

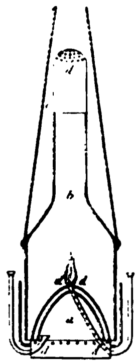


FIG. 10.—MR. G. STEPHENSON'S LAMP.

[Fig. 10] represents this [George Stephenson's] lamp: *a*, the lamp made of copper; *b*, the glass chimney fitted air-tight in the lamp, and . . . . enclosed in a case of tin with holes of about a quarter of an inch in diameter, cut out for the escape of the light; *c*, the cover or tin case so perforated; *d*, *d*, *d*, *d*, air holes. The principle of this lamp is its being supplied with air through small perforations at the bottom.†

APPENDIX B.—IMPORTANT DATES CONNECTED WITH THE COAL-TRADE.

853. Grant of lands by the Abbey of Peterborough: and requires twelve cart-loads of fossil or pit-coal.

1210-1219. Charter of Earl of Winton to Monks of Newbattle granting lease of pit-coal.

1239. Henry III. granted to men of Newcastle-upon-Tyne a licence to dig coal outside the walls.

1246. Coal, having become an article of export, obtained the name of sea-coal.

1283. Municipal statutes of Berwick contain regulations for selling pit-coal alongside vessels importing it.

1424. First Act of the Parliament of Scotland relating to mining.

1555. Dr. Kaye mentions appearance of noxious gases in mines.

1563. Act of the Parliament of Scotland, restraining export of coal.

1590. Dean of York took out a patent to purify pit-coal.

* *A Treatise on the Coal-mines of Durham and Northumberland*, by Mr. J. H. H. Holmes, 1816, page 199.

† *Ibid.*, page 188.

1606. Act of the Parliament of Scotland that no one should employ any person without testimonial showing cause of removal from last master.

1710. Explosion at Bensham colliery and 75 lives lost.

1714. The first steam-engine, north of the Tyne, erected at Byker colliery.

1732. Fire-lamps or furnaces first used at Fatfield colliery, Durham.

1736. Act punishing with death all who set fire to pits.

1760. Carlisle Spedding invented the steel-mill.

1769. Malicious Injuries Act, punishing, with transportation, wilful injury to colliery-property.

1784. Act passed that, in case of any number of persons above five, buying and re-selling coals, they shall be deemed guilty of unlawful combination to advance the price of coals and be liable to be punished by indictment.

1790. John Curr invented underground tramways of cast-iron.

1795. Up to this period, pillars in the deep pits had been given up as lost: the robbing of them was now introduced by Mr. Thomas Barnes, and a quarter of what remained was taken away.

1795. Introduction of cast-iron tubbing in rings at Walker colliery on the Tyne.

1796. Mr. John Buddle put in tubbing at Percy Main colliery, in segments bolted together.

1800. An Act for the security of collieries and mines.

1805. Segments of tubbing were put in, without bolts, at Howden pit; and this method usually adopted in this country ever since.

1807-1810. First mention of mechanical ventilation in the form of an air-pump, at Hebburn colliery.

1811. John Blenkinsopp, of Middleton colliery, Leeds, took out a patent for a locomotive engine.

1813. William Hedley of Wylam colliery on Tyne, took out a patent for a locomotive engine which would draw a load by the friction of the wheels upon the rails.

1814. George Stephenson built a locomotive engine at Killingworth colliery.

[redacted]

1850. Act providing for the appointment of inspectors of mines.
1851. Royal School of Mines inaugurated.
1855. Act to amend the law relating to the inspection of coal-mines.
1860. Act for the regulation and inspection of mines.
1862. Hartley colliery disaster and Act prohibiting single shafts.
1866. Oaks colliery-explosion, where 334 lives were lost.
1872. Act to consolidate and amend the Coal-mines Acts.
1880. Employers' Liability Act.
1887. Act to consolidate with amendments the Coal-mines Acts, 1872 and 1886.
1894. Coal-mines (Check-weigher) Act.
1896. Act to amend the Coal-mines Regulation Act, 1887.
1897. Workmen's Compensation Act.
1900. Workmen's Compensation Act, Amendment.
1900. Prohibition of Child Labour Underground Act.
1903. Act to amend the Coal-mines Regulation Act, 1887 (Granting of Certificates).
1905. Act to amend the Coal-mines Regulation Act, 1887 (Weighing of Minerals).

Mr. J. Nevin, in proposing a vote of thanks to the President, said that he knew from experience the difficulty which there was in finding anything new to say to the members, but Mr. Wilson had surmounted that difficulty with great success.

Mr. H. B. Nash, in seconding the vote of thanks, said that the members had all listened to the address with a great deal of interest and pleasure. It took one back to the days when mining was very different from what it was at the present time, but he thought that they were now only following out the sound principles that were then laid down. As to the future, the President followed almost on the same lines in his address as he (Mr. Nash) had followed when he was president, in expressing the opinion that in a few years, except for winding purposes, nothing but gas and electricity would be used for driving the various engines and machinery about a colliery.

The annual dinner was held subsequently.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,

HELD IN THE HALL OF THE INSTITUTE, HAMILTON, DECEMBER 13TH, 1906.

DR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, who had been duly nominated, were elected:—

MEMBER—

Mr. JAMES SOMMERVILLE, Gatehouse, Climpy.

ASSOCIATE MEMBER—

Mr. ARCHIBALD JARVIE LAIRD, Kelvinbank, Smith Street, Glasgow, W.

STUDENTS—

Mr. REGINALD BUTCHER, 35, Stirling Road, Trinity, Edinburgh.
Mr. GEORGE BROWN CROOKSTON, Myrtle Park House, Crosshill, Glasgow.
Mr. ROHINTAN N. MIRZA, 69, Stanmore Road, Mount Florida, Glasgow.

[redacted]

EFFECTS OF ACCELERATION ON WINDING-TORQUES, AND TEST OF TARBRAX ELECTRICAL WINDING-PLANT.

By GEORGE NESS.

The valuable contribution to the *Transactions*, given by Mr. James Caldwell in his paper upon the electrical installation at the works of the Tarbrax Oil Company, Limited, at Tarbrax and Cobbinshaw,* has induced the writer to offer some remarks upon the effects of acceleration upon winding-torques, and also to place before the members the results of some tests carried out upon the Tarbrax winder.

The peak-load depends upon the acceleration chosen; and, upon the question of the best acceleration-period, members can refer with advantage to the able contribution of Mr. M. Georgi, and the discussion thereon.†

The force required to produce any given acceleration, being designated F, the acceleration by a, the mass moved by M, and its weight by W, and the acceleration produced by gravitation, g, then:—

$$\frac{F}{W} = \frac{Ma}{Mg} = \frac{a}{g};$$

and

$$F = \frac{Wa}{g}. \qquad (1)$$

Let u be the velocity at the beginning of any second of time; v, the velocity at the end of that time; and S, the space passed through in the time under consideration; then:—

$$v^2 = u^2 + 2aS;\ v^2 - u^2 = 2aS;\ \text{and}\ \frac{v^2 - u^2}{2} = aS.$$

Multiplying both sides by the mass, $\frac{W}{g}$, then:—

$$\frac{W(v^2 - u^2)}{2g} = \frac{WaS}{g}.$$

* "Electric Power-station, Winding-gear and Pumping-plant of the Tarbrax Oil Company, Limited," by Mr. James Caldwell, *Trans. Inst. M. E.*, 1906, vol. xxxi., page 221.

† "Notes and Considerations on Systems having Work of an Intermittent and Irregular Character to Perform: Methods of Load-compensation," by Mr. Maurice Georgi, *Trans. Inst. M. E.*, 1904, vol. xxviii., page 89.

And from equation (1), it follows that:—

$$\frac{W(v^2 - u^2)}{2g} = FS. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

FS represents the pull, F in pounds (to produce the given acceleration throughout the seconds of time in question), multiplied by the space S passed through in feet, giving an acceleration-torque, FS, in foot-pounds. To obtain the total energy in foot-pounds developed in this time, the static torque, w (weight in pounds to be lifted) multiplied by S, the space passed through, has to be added. And therefore:—

$$\frac{(F + w)S}{550} = \text{H-P.}$$

Allowing 80 per cent. for the efficiency of conversion, then:—

$$\frac{(F+w)S \times 100}{550 \times 80} = \text{H-P. to be developed by the}$$

winding-engine.

The left side of the equation (2) is the more suitable for use in connection with electrical winding, and gives the energy exerted in producing acceleration during any second of time in terms of the initial and final velocities.

Let W be the weight in pounds of the masses to be accelerated; w, the weight in pounds or unbalanced load to be raised; u, the initial velocity in feet per second; v, the terminal velocity in feet per second; a, the acceleration in feet per second; and g, 32·2. The total torque, T, is equal to the sum of the acceleration-torque and the static torque, that is:—

[redacted]

I. From Table I. will be seen the great increase of energy required to produce rapid acceleration, the peak-load being reached at the end of the acceleration-period. From this instant, only the static torque requires to be dealt with; and this is constant until the beginning of the retardation-period, neglecting the difference in pull due to unbalanced ropes.

TABLE I. – RELATIVE ENERGY REQUIRED DURING THE LAST SECOND OF THE ACCELERATION-PERIOD.

Acceleration-period.	Acceleration per Second. (a)	Velocity at Beginning of Last Second. (u)	Velocity at End of Last Second. (v)	$v^2 - u^2$	Relative Energy to produce Acceleration.
Seconds.	Feet.	Feet.	Feet.		
25	1·00	24·00	25	625 – 576·00	49·00
20	1·25	23·75	25	625 – 564·06	60·94
15	1·62	23·38	25	625 – 546·62	78·38
10	2·50	22·50	25	625 – 506·25	118·75
5	5·00	20·00	25	625 – 400·00	225·00
1	25·00	0·00	25	625 – 0·00	625·00

There is no class of work which presents more obstacles to electrical application than that of winding from mines. The erratic nature of the load, the variations in speed, and the frequency of starting, stopping and reversal, combined with the necessity for absolute control, constitute a grouping of conditions, which, in the earlier days of electrical science, would have been declared insurmountable. Apart altogether from the difficulties of winding, the question of the power-factor is one that has to be considered very carefully from the point of view of efficiency.

In the case of the Tarbrax plant, when it is worked to its maximum, there will be a torque varying from zero to about 280 horsepower thrown on and off every half minute or so. It is only by some such steadying or balancing system, as has been introduced, that a steady voltage could be maintained in the main circuit from which both power and lighting are taken. The writer does not intend to enter into any description of the plant, that having already been fully dealt with by Mr. Caldwell.

In the beginning of July, 1906, at the request of the Tarbrax Oil Company, Limited, Mr. R. D. Munro carried out a series of tests with a view to ascertaining the efficiency of the plant under working conditions, and the writer, being associated with

him in this work, was enabled to make close observations as to the working of the plant. Representatives were also present on behalf of the Tarbrax Oil Company, Limited, and of the contractors who laid down the plant.

Previous to the test, all the instruments to be used were carefully calibrated.

On the three-phase line at the switchboard, an integrating wattmeter of the Ferranti type, No. 95,743, was inserted, and connected up to the neutral point. By this means, the total units delivered to the winding-system during the test were measured. A Thomson direct-reading wattmeter was also inserted into one of the phases. By means of these instruments, the whole power absorbed by the main flywheel motor-dynamo, including the power for excitation, was measured over the time occupied by the test. Instantaneous readings were occasionally taken from the Thomson wattmeter, shewing the power that was being absorbed at any particular period, thus enabling the power-factor to be arrived at, by comparison with the readings on the volt-meter and ampere-meter at the same moment. In the circuit between the flywheel dynamo and the winding-motor, continuous recording ampere-meters and volt-meters of the Nalder-Thomson type with centre zero position were inserted, and a complete register of the current-direction and potential during the different winds was obtained.

The test was started at 10·40 a.m., and continued until 1 p.m., [redacted]

During each wind about 12½ cwts. of shale were raised, the winding-plant being operated at about half the normal output for which it was designed. Table II. records the readings of the Ferranti integrating wattmeter. These results shew that throughout the test the average power-consumption was 0·541 unit per wind; and, allowing 12½ cwts. for each wind, this shews a power-consumption of 0·866 unit per ton of shale raised during the test.

The diagrams obtained from the recording instruments in the continuous-current circuit between the flywheel-dynamo and the winding-motor, are more or less similar in character. For the purpose of calculation, No. 61 diagrams of the volt and ampere records have been selected (Fig. 2, Plate XIII.). From these, a combined diagram (Fig. 3) was prepared, which shewed the total power given out during the wind to be 1,140,412·5 watts, whilst from the winding-motor when acting as a dynamo, 203,000 watts were returned to the flywheel-motor, giving a total consumption of 937,412·5 watts, and this is equal to 0·2603 unit per wind, representing an efficiency of 48¼ per cent.

The winding-motor torque attained the maximum in 5½ seconds after the start of the wind, when the output was 104 kilowatts or 140 horsepower. At the end of 15 seconds, no further power is taken from the flywheel-motor; reversal of the current-direction occurs at the end of 15½ seconds; and, at the twentieth second, there is a maximum of 64·6 kilowatts or 86·6 horsepower being returned by the winding-motor to the source of supply. At the end of the twenty-fourth second, the current rises in a positive direction, and at the end of the twenty-sixth second, it has reached a maximum of 85 amperes, gradually dying away until at the end of 42 seconds it has reached a zero value. The voltage, however, has become zero at the end of the twenty-fifth second, so that there is no loss of power (Fig. 2, Plate XIII.). This rise of the ampere-curve is probably due to residual magnetism, and it is merely referred to, as previous to making an analysis of the ampere-diagram, it gave the impression that a loss of power was occurring.

The power taken to run the flywheel motor-generator from the three-phase mains varied from 15 to 45 kilowatts. This shews greater unsteadiness than was anticipated, but it is explained by the automatic slip-resistance having been designed

for the absorption of a greater maximum power, in the raising of two hutches from the mine, instead of one as at present. Owing to the load being small, the power-factor is also adversely affected, varying from 0·67 to 0·84, and having an average of about 0·7. The low power-factor necessarily lowers the efficiency of the plant, but with a power-factor of 0·9, the efficiency would be relatively high.

With reference to the working of the winder, it ran smoothly, and so quietly that it was practically impossible to tell whether the winding drum and motor were at rest or in motion, unless the eye was turned upon them. The manipulation is simple and easy. The men in charge show complete confidence, and there is no hint of nervousness in the handling of the machine, which is under the most perfect control.

The flywheel motor-generator produced no undue vibration at any alteration of velocity, and the bearings were cool. The whole electrical plant was satisfactory, and the commutation was sparkless during the whole course of the trial.

TABLE III.—ESTIMATED COST OF AN ELECTRICAL WINDING-PLANT.

Generators (including stand-by set), switchboard, buildings, boilers, brickwork, chimney and cabling	£8,500
One-third of this amount is charged against the winding-plant ...	£2,833
Winding-plant, foundations, and buildings	2,800
Total capital charges	£5,633

[redacted]

exact consumption in Board-of-Trade units to wind a ton of material at a certain speed, with an efficiency which must improve as the output is increased to a nearer approximation of the rated tonnage per shift.

In regard to the commercial aspect, there are no figures available, but Table III. contains an estimate of the cost of an installation of similar power which will serve as a guide, and can be used as a basis for the consideration of each individual case.

This estimate includes the cost of 3,000 feet of cabling, all the necessary spare parts, and also a stand-by set. This last item, for ordinary purposes, might be considered unnecessary when spare parts are kept, as the best makers will undertake to deliver duplicate parts within 24 hours. If the standing charges of a stand-by set are deducted from the above estimate, with a corresponding reduction of the capital-charges of the power-station and switchboard, a deduction of £1,000 might be made in the proportionate and therefore total charges against the winding-plant, giving a saving of £100 per annum in depreciation and interest, or 0·07d. per ton, thus reducing the total cost to 0·698d. per ton of shale wound from a depth of 420 feet, with a total output of 640 tons per shift of 8 hours. The efficiency, however, at the rated output must necessarily be somewhat higher than the assumed, which is based on the records obtained during the test, but this will only lower the fuel-cost per ton, the standing charges remaining constant.

DISCUSSION OF MR. JOHN B. THOMSON'S PAPER ON "A DIAMOND HAND-BORING MACHINE."*

Mr. William Smith (Dalmellington) wrote that he had had the hand diamond-boring apparatus at work for over twelve months, and it had given excellent results. The deep hole, mentioned by Mr. Andrew Kyle, was put down by hand-labour to a depth of 639 feet. At that depth, the diamond machine was applied with the result that three times the depth per week was cut, and it cost 5s. less per foot than boring by hand.

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 107.

Mr. Andrew Kyle (Galston) said that. in regard to the point raised by Mr. T. L. Galloway at the last meeting as to the relative cost of diamond-boring by the hand as compared with steam, the advantage was in favour of diamond-boring by hand by about £30, when taken to a depth of 500 feet. When a greater depth than that was wanted, it was desirable to provide against the occurrence of soft strata; and, under such circumstances, the use of a steam-driven machine was preferable. In shales, the chisel-drill was as cheap and as quick, but scarcely as reliable as the diamond-drill; in hard rocks, the diamond-drill was cheaper; and in extraordinarily hard rocks the proportion of advantage was greater, as shown by Mr. Smith's remarks.

Mr. J. Balfour Sneddon (Mid Calder) said that, so far as his experience went, he endorsed Mr. Kyle's remarks. Indeed, he was inclined to think, if Mr. Kyle continued in the progress that he was making, that he would soon be able to put the chisel-drill in an antiquarian museum. It would be used simply to dig holes, allowing the diamond-drill to proceed downward from that point.

Mr. Thomas Thomson said that a bore-hole had been made by a hand diamond-machine since the last meeting. It was started on October 29th, and on December 12th it had reached a depth of 510 feet. Supposing that the cost was more by the diamond-drill than by the chisel-drill, the difference was fully recouped by the amount of time saved.

[redacted]

TESTS OF A MINE-FAN.

BY JOHN B. THOMSON.

The following tests were made on a Capell fan for the purpose of ascertaining whether the combined mechanical efficiency of the fan and of the engine attained 60 per cent. The writer who had been asked to read a paper, having these tests beside him, thought that it would afford a good opportunity of elucidating what seemed to be a mystery or inaccuracy, which will be referred to, after the figures are placed before the members.

The Capell fan is $8\frac{1}{2}$ feet in diameter and $3\frac{1}{2}$ feet broad, getting air at one side and exhausting out of the mine. The diameter of the ear is 5 feet 9 inches, equal to an area of 26 square feet. The fan is driven by a steam-engine with a single cylinder, 9 inches in diameter and 16 inches stroke, having a piston-rod at one end, $1\frac{5}{8}$ inches in diameter. The fan is belt-driven, the ratio of the pulleys being $2\frac{1}{2}$ to 1. One of the pulleys, however, was altered between the first and second tests, making the ratio 5 to 3. The rectangular upcast-shaft, 7 feet long and 5 feet wide, is used exclusively as an air-shaft. The ear of the fan is 18 feet from the edge of the upcast-pit, and the fan-drift is built of brick, with a cement-concrete roof and floor.

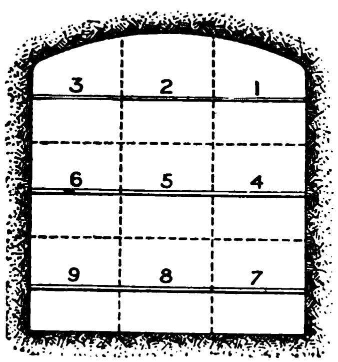


FIG. 1.—FAN-DRIFT.
SCALE, 4 FEET TO 1 INCH.

All the tests were made when the pit was entirely clear of workmen.

I. The first test was made on September 23rd, 1905. When the engine was running at 90 revolutions and the fan at 225

revolutions per minute, four indicator-diagrams were taken from each end of the cylinder, shewing a mean pressure of 54·895 pounds per square inch and 24·98 horsepower.

The air was measured in the fan-drift, about midway between the upcast-shaft and the fan. The drift was divided into nine spaces (Fig. 1), and shelves were placed in the centres of the spaces to support the three anemometers, which were used, after being calibrated at Kew. The anemometers were allowed to run for 5 minutes in each space, so as to get a fair average. The results of these tests are recorded in Table I. It will be noticed that the quantities of air in Nos. 1 to 6 spaces were positive, and that they were negative in Nos. 7, 8 and 9 spaces. The average speed of the engine, when the air was being tested, was 92 revolutions and of the fan 230 revolutions per minute, so that the power in the air at 90 revolutions per minute should be (22·42 × 90 ÷ 92 or) 21·93 horsepower. The mechanical efficiency was (21·93 × 100 ÷ 24·98 or) 87·8 per cent. When these figures were worked out the result seemed to be absurd, and it was decided to make another test.

II. The second test was made on October 14th, 1905, and, as already mentioned, the ratio of the pulleys had been altered since the first test. In this case, the speed of the steam-engine

TABLE I.—RESULTS OF EXPERIMENTS UPON A CAPELL FAN.

No. of Space	Area of Space	Velocity of Air per	Quantity of Air per Minute	Water-	Horsepower in the Air

[redacted]

The air was measured in the fan-drift as in the first test. The top shelf having been broken, a new one, a little thicker, was substituted, and made a slight difference in the area of the spaces. Table II. shews the results of this air-test, and it will be again noticed that the readings are positive in the first six spaces and negative in the last three spaces. The horsepower in the air being 18·38, and that of the engine, 21·27, the mechanical efficiency was 86·4 per cent.

TABLE II.—RESULTS OF EXPERIMENTS UPON A CAPELL FAN.

No. of Space.	Area of Space.	Velocity of Air per Minute.	Quantity of Air per Minute.		Water-gauge.	Horsepower in the Air.	
	Square Feet.	Feet.	Cubic Feet.	Cubic Feet.	Inches.	Horse-power.	Horsepower.
1	3·930	3,981	15,645		1·93	4·76	
2	4·500	3,565	16,042		2·11	5·33	
3	3·930	3,225	12,674		2·09	4·17	
4	3·725	2,531	9,428		1·90	2·82	
5	3·725	1,541	5,740		1·86	1·68	
6	3·725	1,653	6,157		1·86	1·80	
			——	65,686		——	20·56
7	3·725	− 506	− 1,885		1·80	−0·54	
8	3·725	−1,009	− 3,758		1·81	−1·07	
9	3·725	− 545	− 2,030		1·78	−0·57	
			——	− 7,673		——	− 2·18
Totals	34·710	—	—	58,013	1·90	—	18·38

III. The results of the two tests, being so near one another, pointed to some other reason for the high efficiencies shewn than inaccurate testing; and, seeing that there was such an eddy in the fan-drift, it was decided to make another test and measure the air at the bottom of the upcast-shaft. A rather unusual circumstance at the colliery allowed this to be done with very little trouble. The upcast-shaft is sunk to the Ell coal-seam a depth of 324 feet. This seam is not being worked at present, and a short drift, 120 feet long, leads from the bottom of the upcast-shaft to the top of a blind pit, sunk to the lower seams now being worked and ventilated, so that all the air that goes to the fan passes through this drift on its way to the upcast-shaft.

The third test was made on November 11th, 1905. The steam-engine was running at a speed of 120 revolutions and the fan at 200 revolutions per minute. The mean indicated pressure taken from 12 diagrams was 33·89 pounds per square inch, and the engine produced 20·56 horsepower. The quantity of air passing

through the drift in the Ell coal-seam was 43,035 cubic feet per minute; and the observations recorded in Table III., were taken, in order to calculate what the volume should be in the

TABLE III.—OBSERVATIONS IN THE ELL COAL-SEAM.

Barometer, at surface	29·08 inches.
Do. , at Ell coal-seam, downcast side ...	29·44 ,,
Thermometer, at surface, in atmosphere ...	52° Fahr.
Do. , in fan-drift	62° ,,
Water-gauge, in fan-drift	2·03 inches.
Do. , in Ell coal-seam	1·16 ,,

fan-drift. The difference of ($2·03 - 1·16$ inches or) 0·87 inch in the readings of the water-gauges is equal to 0·06 inch of mercury; and, consequently, the actual barometric pressure in the Ell coal-seam would be equal to ($29·44 + 0·06$ or) 29·50 inches of mercury. The volume of air, calculated at the pressure in the fan-drift, would consequently be ($43,035 \times 29·50 \div 29·08$ or) 43,656 cubic feet per minute. The water-gauge due to the differences of temperature, calculated on the depth of the Main coal-seam, 393 feet, was 0·11 inch; and the actual water-gauge due to the fan was ($2·03 - 0·11$ or) 1·92 inches. The horsepower of the ventilation is ($43,656 \times 1·92 \times 5·2 \div 33,000$ or) 13·20. The mechanical efficiency was ($13·20 \times 100 \div 20·56$ or) 64·2 per cent.

This result seems to be a nearer approach to the real efficiency than that obtained in the two former tests, and the question arises as to why the anemometers should register a greater velocity in the fan-drift than is due to the quantity of air actually

[redacted]

have been measured in the fan-drift had it been made during the third test, would have been (40,964 : 43,035 : : 56,033 :) 58,865 cubic feet per minute; the horsepower of the ventilation would have been ($58,865 \times 1.92 \times 5.2 \div 33,000$ or) 17·8; and the mechanical efficiency would have been ($17.8 \times 100 \div 20.56$ or) 86·5 per cent.

From the results of these tests, it seems to be incorrect, when testing a fan for its mechanical efficiency, to measure the quantity of air in the fan-drift, as the velocity of the air, taken so near the fan, is influenced by it in the same way as air rushing through a regulator, when a factor has to be introduced to allow for *vena contracta*.

Mr. L. H. Hodgson read the following paper on "The Wolf Safety-lamp":—

THE WOLF SAFETY-LAMP.

By L. H. HODGSON.

On July 3rd, 1835, Mr. John Buddle, in giving evidence before a Select Committee on Accidents in Mines, stated, in regard to the coal-mines in the Lothians and Fifeshire, that very little fire-damp was met with in them, " so trifling that it is not worth while naming them. . . . You have to search for gas as a curiosity in them."* How often it happens, where fire-damp is only to be found so very rarely, that accidents occur. Seeing no danger for so long, one is apt to become careless in the examination of workings, and when gas is detected it comes as a surprise, and disaster often follows. It has been authoritatively stated that a mine known to give off gas is safer than one where the danger arises only at very wide intervals, as it tends to keep the officials on the alert. And, when detected, how necessary it is to know in what proportion in relation to the air the danger exists: remembering that should there be 9½ per cent. of fire-damp, the mixture is at its highest explosive point.

Now, when one has a real safety-lamp, such as the Wolf, this danger can be ascertained when only ¾ per cent. of fire-damp is present. This percentage has been established by the Pieler [redacted]

pressed cold, and when finished it is doubly tinned (thus preventing corrosion), previous to which the top cover containing the wick, igniter and filling apparatus is fixed, and the vessel filled with specially prepared cotton-wool (⅜ ounce, which has a maximum absorption of 30 drachms). The wick is brought to the bottom of the vessel, and is so regulated by the wick-adjuster that it is impossible to obtain a smoky flame—thus lengthening the life of the gauzes, and assuring a clear light throughout the shift. It is necessary, before this can be attained, to burn a lamp, when first it is used, for a few minutes, and then the lamp-attendant will determine how much wick should be left above the wick-tube, so as to afford the maximum of light without smoking.

The friction-igniter consists of a metal box fitted with a scratcher and a hinged door, to the outside of which is fixed a thumb-spring for fixing it into position. The pull-bar, to which a scraper is attached, is placed (after the igniting strip is fitted into position) so that the scratcher and scraper come together, causing an ignition of the cap on the strip, and thus the wick is lighted.

To fill the oil-vessel, so that only sufficient benzine is absorbed by the cotton-wool (allowing of no waste) and that no liquid be left unabsorbed in the vessel, an automatic filling apparatus has been introduced; it is fitted with one or more taps, as may be found necessary. A glass reservoir is placed above the tap, with a capacity of 2 ounces (slightly more than the maximum absorption of the cotton-wool), and at the top a brass tube is inserted, extending on the outside to near the top of the tank, it is then bent and brought downward to the mouth of the tap. As soon as the cotton-wool has absorbed sufficient benzine, air rushes up the tube and prevents any further flow; and, consequently, should an oil-vessel, containing, say, 9 drachms, be put under the tap, only 21 drachms more will be added before the charging is automatically stopped. The top of the tank is provided with a safety-valve and inner cylinder, covered with wire-gauze (784 meshes per square inch) which allows any excess of air and vapour to escape. The larger apparatus, fitted with two or more taps, is placed on a cast-iron stand, and is additionally provided with a glass-guage, a wing-pump, and circular stands, carrying the oil-vessels, and these are, by a lever and

counterbalance weight, brought up to the required height for filling. The wing-pump is attached by a pipe ½ inch in diameter to the storage-vessel placed adjacent to the lamp-room, so that the attendant never needs to handle the liquid. The capacity of the tanks varies from 9 to 19 gallons.

To ensure the safe locking of the lamp, the oil-vessel is provided with two threads, with a maximum thickness of ⅛ inch, in which three apertures are cut; into these the anchor-head of the magnetic lock successively falls, when the parts of the lamp are fitted together, three distinct clicks being heard.

The standard brass-ring contains the magnetic lock, which is dust-proof. The air-inlet ring is fitted with double wire-gauze, and, for fixing the same firmly against the glass cylinder, it is provided with two small projections, which are forced by a circular key through small slots in the standard ring, upon which they ride and are turned back to the check placed upon this ring. Perpetual washers are used for all joints, and they have been found to be more durable than asbestos.

Inside the top ring supporting the bonnet, a series of strong steel springs are fixed: they hold the glass firmly in position, and are of such a tension that they take up the little expansion of the glass that takes place whilst the lamp is in use. The bonnet is made of seamless steel, pressed cold, and is treated in a similar manner to the oil-vessel. Both the inner and outer gauzes are fitted with fixed copper rings, which ensures that their normal shape will be maintained while being cleaned. The inner gauze

[redacted]

mines, for the usual velocity in a main intake is, say, 12 to 15 feet per second, and round the face, say, 5 to 8 feet per second. Of course, one may get a velocity of 90 feet per second, when cages are running in an upcast shaft; but no safety-lamp yet manufactured can withstand such a velocity, excepting an electric lamp. As before stated, the Wolf safety-lamp is capable of detecting as low as ¾ per cent. of fire-damp, a matter of much importance. The Wolf lamp is fitted with a flat wick ⅝ inch wide, and gives a light equal to 1·43 candlepower; and, fitted with a round wick, it produces a light of 1·02 candlepower. This latter is, however, much higher than the candlepower of most other types of safety-lamps. The time of burning of this lamp is 16 hours when fitted with a flat wick, and 20 hours when fitted with a round one.

Remembering that a lamp fitted with a flat wick, ⅝ inch wide, when fully charged with 30 drachms, burns 16 hours, therefore, while burning 9 hours it will consume 16·88 drachms or 84·40 drachms during five days; and at 7d. per gallon, the cost will be 0·46d. per lamp for a week of five shifts. With a round wick, this cost is reduced to 0·37d. per lamp for five shifts. The oil-vessel will only require to be loaded with the maximum charge, 2·81 times during the five shifts for a wick ⅝ inch wide, and 2·25 times for a round wick. The life of the cotton-wool is considerable, it having been known to last 14 years; but, should inferior benzine be used, the wool becomes choked with impurities, and its life is materially curtailed. When it is necessary to replace the wool, this is readily effected by withdrawing it through the filling aperture.

Numerous severe tests have been made as to the safety and efficiency of the Wolf lamp by wellknown and recognized authorities: for instance, the Royal Saxon Mining Commission, strongly recommended the use of this lamp in all collieries.* The Prussian Fire-damp Commission tested the Wolf lamp many times with every success.† Other mining commissions have similarly expressed their approval, and Mr. G. Chesneau, the inventor of the Chesneau gas-testing safety-lamp, has reported

* "Untersuchungen über Sicherheitslampen," by Messrs. G. Kreischer and Cl. Winkler, *Jahrbuch für das Berg- und Hüttenwesen im Königreiche Sachsen*, 1884, part i., page 52; and *Trans. N.E. Inst.*, 1885, vol. xxxv., page 13.

† *Trans. Inst. M. E.*, 1893, vol. v., page 501.

to the French Fire-damp Commission as to the advantages of the Wolf safety-lamp.*

Owing to the Wolf lamp being fitted with an internal friction-igniter, it has been the means of saving hundreds of lives in mines. The Courrières disaster on March 10th, 1906, would not have been so appalling if those who survived the explosion had been able to relight their lamps. In that disaster, 13 workmen, led and encouraged by a miner called Nemy, were not rescued until 21 days had elapsed, and a large percentage of the 1,100 killed had succumbed, as proved by post-mortem examination, several days after the explosion. The colliery is now equipped with 4,000 Wolf safety-lamps.

The PRESIDENT (Dr. R. T. Moore) said that the idea of the igniter appeared to be a good one, and he did not think that the Coal-mines Regulation Act would prohibit its use. The object of the regulation was obviously to prevent men from having a naked light in a fiery mine; but, so long as the igniter was placed inside the lamp, there seemed to be no contravention of the law. He understood that the Wolf safety-lamp was largely used on the Continent with satisfactory results. Recently, there seemed to be a feeling amongst inventors of safety-lamps that it was desirable to get a fireman's lamp which would detect 0·16 per cent. of fire-damp. He rather thought that this was a misapprehension, and it ought to be corrected.

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ACETYLENE SAFETY-LAMPS.

BY L. H. HODGSON.

As long ago as 1836, Prof. E. Davy, of the Royal Society, Dublin, accidentally discovered acetylene gas, by making a carbide with potassium and noting that it decomposed in water, and that the resulting gas burned with a brilliant flame. But it was not until 56 years after, namely, in 1892, that calcium carbide (CaC_2) was produced at a commercially cheap rate by Prof. H. Moissan, who, by chance, whilst conducting experiments with an electric furnace, noticed that the walls of the furnace, consisting of lime, fused into a liquid state at 3,000° Cent., and that a combination, between it and the carbon of the electrodes, produced calcium carbide. Oddly enough, during the same year, Mr. T. L. Willson, by accident also, whilst experimenting upon the reduction of metallic substances in a similar furnace, found, having had lime with tar and other forms of carbon in the furnace, "a hard crystalline mass" which gave rise to a violent evolution of gas when brought into contact with water, the gas being inflammable and burning with a smoky flame. This discovery by Mr. Willson resulted in the manufacture of calcium carbide on a large scale at Spray, in North Carolina.

The materials used for the manufacture of calcium carbide are quicklime and coke. Care must be taken in selecting a lime free from such impurities as phosphorus, sulphur, magnesium, aluminium and silicon, and the burning is done in gas-kilns so as to prevent the fuel from affecting the resulting lime. Mountain Limestone is generally used, as it sometimes contains 99 per cent. of pure material. The carbon used is usually coke; but it is possible to use anthracite or charcoal: the former, if pure, answers well; but the latter often contains a quantity of phosphorus, and is not easy to use.

A good quality of foundry or furnace-coke, specially prepared, is suitable for making carbide. It is manufactured from a moderately bituminous coal, burnt in a specially prepared

oven, the coal being crushed fine, screened and washed. The proportions are 100 parts of lime to 68 or 70 of coke, and both ingredients are ground to a fine powder.

After numerous experiments, extending over several years, a safe and efficient acetylene safety-lamp has been introduced. It will only be necessary to point out the slight differences of construction as regards the treatment of the calcium carbide in the benzine safety-lamp. The oil-vessel becomes the receptacle for the calcium carbide, and is filled two-thirds full, thus allowing one-third for the expansion of the carbide when saturated with water. The upper vessel or the water-container is fitted with a filling aperture, an internal friction-igniter operated from the outside, and a water-and-gas shut-off, which comes into action separately, that is, when the outside lever is turned 45 degrees from left to right, the water is shut off and no further generation of gas takes place, but the lamp continues to burn and the residue is consumed in a few minutes; but should the lamp need to be instantly extinguished, the lever is turned the full 90 degrees, or as far as the lever will go. The gas thus enclosed gradually escapes through the by-pass. A safety-valve or by-pass is placed adjacent to the burner. Should the lamp be required immediately after it is extinguished, it is advisable to allow, say, five seconds to elapse before bringing the internal friction-igniter into operation, as the pent-up gas issues with extra velocity, producing, when lighted, a slight puff, which

to the size of the lamp. The carbide-chamber, for 6 hours' burning, when three-quarters full, contains 4 ounces. Carbide may be purchased in quantities at 3d. per pound, and consequently the cost will be 0·125d. per hour, per 10 candlepower, or 3·75d. for 5 shifts of 6 hours.

The large acetylene safety-lamp, of 60 candlepower, is fitted with a water shut-off, which considerably assists in the economical burning of the lamp, as hitherto, it has been necessary to regulate the charge of calcium carbide to the time that the lamp is required to burn. The carbide-chamber, for 20 hours' burning, is filled with 3¼ pounds. The cost of burning is slightly less than ½d. per hour, or 0·008d. per candlepower per hour. The working of this lamp is in every way similar to that of the small safety-lamp, except that it is fitted with four water-droppers, which must be seen to be dropping freely, before it is fixed to the carbide-container.

The PRESIDENT (Dr. R. T. Moore) remarked that the acetylene lamp afforded a very brilliant and luminous light. Might not, however, the heat from the lamp be an objectionable feature in handling?

Mr. L. H. HODGSON said that this type of lamp was being used officially in mines in Great Britain, but not at present by the workmen. The acetylene safety-lamp certainly did become hot when held stationary, but it was easily handled, when used in the examination of mines. He believed that one lamp would do for two miners.

The discussion was closed, and a vote of thanks was accorded to Mr. Hodgson for his interesting papers.

THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE UNIVERSITY, BIRMINGHAM, OCTOBER 22ND, 1906.

MR. F. A. GRAYSTON, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected:—

HONORARY MEMBER—

Mr. HUGH JOHNSTONE, H.M. Inspector of Mines, Stafford.

MEMBER—

Mr. ROBERT WILLIAM PERRY, Ipok, Perak, Straits Settlements.

STUDENTS—

Mr. ASOK BOSE, The University, Birmingham.

Mr. IRA CYRIL FRANK STATHAM, Clayhanger, Brownhills.

[redacted]

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1906. Cr.

	£	s.	d.		£	s.	d.
Balance in bank ...	204	14	1	The Institution of Mining Engineers ...	93	2	0
Subscriptions received ...	172	12	6	Rent and cleaning of rooms ...	20	0	0
Bank-interest ...	3	2	6	Secretary's and reporter's salaries ...	50	0	0
Sale of *Transactions*, etc. ...	1	7	6	Printing, stationery, etc. ...	8	17	0
				Postages, telegrams, auditor's expenses, etc. ...	8	4	5
				Balance in bank ...	201	13	2
	£381	16	7		£381	16	7

BALANCE-SHEET, 1906.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
The Institution of Mining Engineers ...	49	6	7	Subscriptions due ...	168	0	0
Balance ...	320	6	7	Balance in bank ...	201	13	2
	£369	13	2		£369	13	2

Examined and found correct,
WILLIAM H. WHITEHOUSE,
Auditor.

October 22nd, 1906.

This balance is exclusive of considerably more than £100 worth of property, for which no credit is taken.

The Annual Report of the Council and the Treasurer's Accounts were read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1905-1906.

The Council report that during the past year there has been an improvement in regard to membership, there being a net increase of 6, bringing the total to 180, as against 174 last year.

They regret to record the death of Mr. William Nowell, a wellknown member in Warwickshire.

The receipts for the year are rather less than usual; the expenditure being about the same, there is a small deficit of £3 0s. 11d.; and the bank-balance now stands at £201 13s. 2d. The arrears of subscriptions are large, amounting to £168.

The Committee appointed to investigate the method of working the Thick coal-seam of South Staffordshire and Warwickshire has held several meetings during the year, and a list of questions was sent to all members and others who were in a position to give information regarding the past and present methods of working the Thick coal-seam. The questions were also printed in the *Transactions*, but the Council regret to report that the Committee has met with very meagre support, and would urge members who are possessed of valuable and useful information to kindly place the same in the hands of the Committee, so that it may be put on permanent record in the *Transactions* of [redacted]

Council resolved, at the meeting of February 5th, 1906, to make the experiment of holding the meetings of the Institute alternately with Birmingham, at Dudley, at Walsall, and at Nuneaton. The first meeting under the new arrangement was held at Dudley, on April 4th, 1906; and, after a conference with the Walsall members, the meeting for that town has been held over until December.

The Institution of Mining Engineers continues to make very satisfactory progress. There has been a substantial increase in the membership, and 64 papers have been read before the local Institutes during the year.

A sub-committee was appointed to consider the administration of The Institution of Mining Engineers, and their report is a very favourable one indeed. They were able to get a reduction of £170 per annum in the cost of the *Transactions*, and on all other points the investigation was most satisfactory.

The thanks of the Institute are due and are hereby tendered to the University of Birmingham, for providing rooms for the use of the Institute.

The PRESIDENT moved a hearty vote of thanks to Mr. W. N. Atkinson, the retiring president, and to the other officers, for their services during the past year.

The motion was put and carried unanimously.

The PRESIDENT (Mr. F. A. Grayston) delivered the following address:—

PRESIDENTIAL ADDRESS.

By F. A. GRAYSTON.

I must first thank you for having elected me your President for the ensuing year, an honour which I much appreciate, particularly when I bear in mind the number of eminent men who have filled the presidential chair of this Institute in the past. It will be my endeavour to promote the best interests of the Institute during my year of office, and I feel sure that I shall be supported in my efforts by the whole of the members.

The Secretary has read his report on the result of the work done during the past year, from which it appears that the number of members has increased, and that the financial position of the Institute is satisfactory.

The papers read during the past year have been of an instructive and interesting character, and our best thanks are due to those members who have kindly taken the trouble to write them; and I need hardly say that the Council will be pleased if they will furnish further papers, although it is not quite reasonable for the whole of this work to be done by one section

[redacted]

owing to the extension of mines beyond the area of the visible coal-fields.

In our own immediate neighbourhood, there is ample room for investigation and study of this science. I need not do more than refer to the geological knowledge of a prominent and most useful member of this Institute in his lifetime, the late Mr. Henry Johnson, as it enabled him to form a reliable opinion as to whether or not the Staffordshire Thick coal-seam extended under the red rocks, which bounded the eastern side of the coal-field, and ultimately led to the establishment of the Sandwell Park, and afterwards of the Hamstead colliery. Both of these collieries were sunk through strata then regarded as Permian, but now known as the Keele series, lying at the top of the Carboniferous system.

Since that time, extensions have taken place in the same manner in Warwickshire on the western side of that coal-field, and I think that it would be of interest to the members if I laid before them some data which I have on the subject of a possible further extension of the Coal-measures under the Keele series, and the New Red Sandstone, which intervene between the eastern boundary of the South Staffordshire coal-field and the western boundary of Warwickshire (Plate XIV.).

The distance between the visible portions of the two coal-fields at the nearest point, situate towards the northern end of each, namely, Aldridge in Staffordshire, and Wilnecote in Warwickshire, is about 10 miles. The farthest distance intervening is at the southern end of the two coal-fields, namely, from the neighbourhood of Halesowen, East Worcestershire, to Craven colliery, near Coventry, Warwickshire, the distance being about 22 miles.

The intervening rocks at the surface starting from Aldridge are Bunter conglomerates, which extend to Hints in Warwickshire, a distance of 6½ miles, except a patch of Permian strata near Little Aston, and another at Hints. At the last-named place, a fault dipping eastwards shows the Keuper marls at the surface, and they continue to Fazeley close to the western side of the Warwickshire coal-field. A large fault, running near here in a north-easterly direction having an upthrow to the south-east, brings the Coal-measures to the surface. It can be traced in a north-easterly direction for some miles, but southward the

course of the fault is hidden by the alluvium of the river Tame, and it is difficult to say how far it extends in that direction. The throw of this fault has not yet been proved, but it is probably of considerable magnitude.

Some of the Seven-feet coal-seam has been worked near Tamworth on the upper side of a large fault, corresponding in position with this one, and the Coal-measures were found on the downthrow side of this fault at a depth of some 510 feet from the surface, so that the throw must be less than that, or the strata are thrown down by a series of smaller faults.

At the southern end of the Staffordshire coal-field, starting from near Halesowen and proceeding eastwards, after passing over a short distance of the Keele and Bunter series, the Keuper is found at the surface and extends to the Keele rocks lying to the west of the Craven colliery, near Coventry. Situate midway between these two extremes, there is Sandwell Park colliery in Staffordshire, and, nearly due east of the same, the Arley colliery in Warwickshire, the intervening rocks at the surface being practically the same as those that I have just mentioned.

We thus have on the eastern side of the exposed South Staffordshire coal-field, from a little south of Aldridge down to the extreme southern end, the Keele series, and the same on the western side of Warwickshire from Kingsbury to Craven colliery. The Tunnel and Newdigate collieries have been sunk through these rocks, within recent years, on the Warwickshire side, and,

[redacted]

positions of these coal-seams are practically summarized in the *Report of the Royal Commission on Coal-supplies*, which reads as follows:—

In the northern section, the productive Coal-measure series contains many workable coal-seams, of which the chief are the Deep, Shallow, Cinder, Bass and Yard, the Old Park, Four-feet, Five-feet, the Brooch, and some upper seams. This nomenclature applies to the centre of the Cannock Chase districts, but the names of several of the seams vary within short distances. When followed from north to south through the coal-field, the South Staffordshire productive Coal-measures, as already pointed out, decrease in collective thickness. Owing to the gradual dying out of the intervening sandstones and shales, some fourteen of the coal-seams of the northern district come together, to constitute the famous Thick coal of the southern section (or Thick coal district). The Deep coal and the Shallow coal unite to form the Bottom coal, and the Bass and the Yard to form the New Mine. In addition to these, the chief of the coal-seams of the southern district are the Heathen and the Brooch coal, the last lying at the top of the productive series. South of an east-and-west line, drawn from Birmingham to Stourbridge, the coal-seams of the South Staffordshire productive series begin rapidly to deteriorate; owing to the intermixture of clayey and non-carbonaceous matter with the coals. A line joining the Manor pits, near Halesowen, with the sinking near Wassel Grove, may be looked upon as marking the practical limit of the profitable Staffordshire coal-seams in the southern direction.*

Besides the coal-fields in South Staffordshire enumerated in the extracts that I have just read, there are numerous beds of ironstone; but for my present purpose I will refer only to the Gubbin ironstone immediately below the Thick coal-seam, and to the New Mine or White ironstone found a few feet above the Sulphur coal-seam.

Turning to the Warwickshire coal-field, it may be divided into the northern or Tamworth division and the southern or Nuneaton division. There are certain characteristics pertaining to each division, but the various workable coal-seams extend, speaking generally, over the whole coal-field. The Seven-feet seam is the most persistent, and whilst at the Tamworth end it varies from 5 to 6 feet in thickness, and in one or two instances even more, it gradually thins as it approaches the southern end. This remark also applies to the coal-seams below the Seven-feet seam, whereas those above attain a greater thickness as they go southward. The intermediate strata, consisting of shales, sandstones, and marls, also diminish in thickness as they approach the southern

* "Report on the Available Coal-resources of District B (Staffordshire, Warwickshire, Leicestershire, Shropshire, and a small portion of South Derbyshire)," by Prof. Charles Lapworth and Mr. Arthur Sopwith, *Final Report of the Royal Commission on Coal-supplies*, 1905 [Cd. 2355], part iii., page 4.

end of the coal-field—for instance in the neighbourhood of Tamworth the total depth of strata from the Seven-feet coal-seam to the topmost seam is about 400 feet. They diminish to 270 feet at Baddesley colliery, near Atherstone, and to 70 feet at Hawkesbury colliery, near Bedworth. The coal-seams, found at the last-named colliery, above the Seven-feet coal-seam, attain a thickness of 27 feet 7 inches, including 2 feet 11 inches of partings, clay and marls.

In the Tamworth division, the Thin coal-seam, lying immediately above the Seven-feet seam, is separated at some places by only a few inches of bat, and in other parts of the same district by several feet. The upper portion of the seam is of a sulphurous nature. Above this, there are some ten thin seams of coal, the aggregate thickness of which is 22 feet, but all coming close together in the neighbourhood of Bedworth. Below the Seven-feet seam, the Double and Bench coals are worked to a limited extent, but they are tender and not generally regarded with favour by colliery-owners.

Whilst in the northern end the seams are nearly level, they lie at a great angle of dip at some of the older collieries in the southern end. At Ansley Hall colliery, the dip for nearly 2,700 feet from the shaft is 1 in 2; still further south, at Wyken colliery, the Coal-measures dip at an angle of 21 degrees westwards for some distance; and at the Craven colliery, the southernmost colliery in the coal-field, but now closed, the dip is as much [redacted]

At Kingsbury colliery, situate some 6 miles to the north-west of Arley, where the shafts are in the Coal-measures, the depth to the Ryder seam is 634 feet, and to the Seven-feet seam, 879 feet. It is noticeable that the strata intervening between the coal-seams are thinner than at Hall End colliery, situated about 2 miles north-east. At Kingsbury colliery, although the shafts are sunk to the Seven-feet seam, that seam is no longer in work there, owing to its inferior quality—in fact, it generally deteriorates from the village of Wilnecote to Kingsbury colliery. Considerable difficulty, entailing a great outlay, has been incurred in proving the Ryder seam at this colliery, and there was practically no Ryder coal between the two shafts. It was found near the southern shaft, and two main roads were started in a south-westerly direction in the coal. It was, however, lost sight of after driving 240 feet; the roads were continued for 345 feet, when the coal was again found, but only to be lost after driving in it a further distance of 480 feet, and not found again until an additional 1,620 feet had been driven in barren ground. At that point the coal was again met with, and has been worked regularly ever since. This barren ground is undoubtedly a wash-out fault, of which there is ample evidence underground. The owners are entitled to our congratulations on the result of their untiring and courageous efforts to prove the existence of this coal at their colliery.

It is worth while to notice that, though the Coal-measures in the Nuneaton district dip to the west, those at Arley rise to the west, and it is not improbable that, when the Coal-measures at Nuneaton have dipped for a mile or so in length, the dip lessening as the seams extend to the west, eventually finding the horizontal position, they may rise in the opposite direction, and thus correspond with the dip at Arley.

As is well known to the members, borings have been made in recent years to test the existence of the Coal-measures under the red rocks lying between the two coal-fields, with varied success. Whilst coal-seams were found at a depth of some 1,800 feet by a bore-hole near Packington, the boring at Little Aston, near Streetly, has not been successful, as the depth of 1,950 feet was bored in the red rocks all the way and no Coal-measures were reached.

Other bore-holes have been put down between Packington and Coventry, and if any of the members are acquainted with the section of the strata passed through, I am sure that the Council will be pleased to receive any information that can be given with respect to them.

Meanwhile, it may perhaps be interesting to consider how far identification of the coal-seams in the two coal-fields can be made. I have given some consideration to the matter, but have confined myself, so far as South Staffordshire is concerned, to the Thick coal-area south of the Bentley fault, as, on looking at the Geological Survey map it appears to me to be probable that this part of the coal-field could be more definitely correlated than the area north of the fault.

As already mentioned, the most persistent seam of coal in Warwickshire is the Seven-feet, and I have many reasons for believing that it is identical with the New Mine coal-seam of Staffordshire. The Thin coal over the Seven-feet coal in that case is the Sulphur coal of Staffordshire, and the ironstone usually found at a distance of some 21 feet above the Warwickshire Thin coal is the New Mine or White ironstone of Staffordshire.* The Smithy coal-seam of Warwickshire, with the ironstone measures above, I consider to be the Heathen coal and Gubbin ironstone of Staffordshire, and the nine or ten thin coal-seams above the Smithy in North Warwickshire, measuring [redacted]

is nothing inconsistent in concluding that the seams in each district are identical.

Although it may often be necessary, in order to make a complete correlation of coal-seams, to call in the assistance of the palæontologist, I think that there is in this instance sufficient information apart from this to justify the conclusion that the seams of the two coal-fields are the same.

Of course, even if this be taken for granted, there is the all-important question as to how far they extend under the area of the intervening red rocks. There is the risk that the Silurian rocks underneath may prevent the Coal-measures from existing in an extensive area without interruption. In fact, Prof. Edward Hull has given an opinion that these two coal-fields are one, but divided to some extent by tongues of older rocks.* Whether this be so or not, the whole question is one of great importance to everyone having an interest in the mineral resources of this district, and I have no doubt that it would be a source of profit and pleasure to any member who might take it up. I hope that these may not be few in number, and that they will lay before the members the result of their work.

A vote of thanks was accorded Mr. Grayston for his interesting address.

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* *The Coal-fields of Great Britain*, by Prof. Edward Hull, fifth edition, 1905, page 276.

THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE GEORGE HOTEL, WALSALL, DECEMBER 5TH, 1906.

MR. F. A. GRAYSTON, PRESIDENT, IN THE CHAIR.

The minutes of the Annual General Meeting and of Council Meetings were read and confirmed.

[redacted]

BOILERS FOR COLLIERY PURPOSES.

By F. C. SWALLOW.

Of the variety of subjects upon which the modern colliery manager is required to direct his attention, the important question of the most economical and efficient means of generating his steam-supply is frequently neglected. The steam-consumption at different collieries varies in a remarkable degree, and may range in coal consumed (at the boilers) from as low as 1½ per cent., to as much as 11 per cent. of the total output, when the collieries under comparison are working full time. Thus, taking as an example the standard of output as 1,000 tons per day, from a depth of 1,000 feet, when the conditions of haulage, pumping and winding are approximately similar, and placing the value of the fuel at 1s. per ton in each case, this price representing the commercial value of the fuel in the books of the company, the coal-bill for an annual output in each case of say 250,000 tons is equivalent to about £187 10s. per year, when the colliery-consumption is 1½ per cent. of the output, and to £1,375 per year when the colliery-consumption is 11 per cent., or a difference in favour of the economically managed colliery of no less than £1,187 10s. per year, in the coal-bill alone, irrespective of labour and cost of maintenance. It is obviously difficult to make a fair comparison of collieries in this respect, as the circumstances and conditions may be so vastly different; at the same time, there are undertakings where the above illustration can be applied.

The original boiler-plant of a colliery may have performed good service; but, owing to inevitable depreciation of the boiler-plant and engines, and the consequent reduction of the working pressure, a state of affairs may have been reached after an extended term of years, when a considerable waste in fuel and in engine-power exists, and losses occur which cannot be remedied unless a complete replacement is made. The writer has experienced the work of having to replace, with Lancashire boilers, a whole range of egg-ended or cylindrical boilers, which

had become exceedingly wasteful, and were, besides, unable to maintain the supply of steam demanded of them, owing to general depreciation, on two separate occasions, and at the same time maintain the output of the collieries. In both instances, when a centralization of power and more efficient steam-plant had been installed, the coal-bill fell from its original level of between 10 and 12 per cent., to an average of about 6 per cent. of the total output.

Of late years, the increased application of electricity as a motive power, instead of steam, for colliery-work has greatly reduced the colliery-consumption, and this is a means whereby old boiler-plants may be, in some instances, almost wholly dispensed with, whilst at the same time no loss of output is caused. A central power-station for a group of collieries is the ideal arrangement, when circumstances admit of the outlay which such a scheme involves.

The colliery-consumption of the majority of collieries in the district embraced by this Institute ranges from 6 to 11 per cent. of the output. Thus, taking the output during the year 1905, namely, about 16,500,044 tons, this is equivalent to a consumption of from 1,000,000 to 1,750,000 tons of fuel per annum for steam-generation at the collieries of the district. Although the commercial value of the fuel will not exceed about 2s. 6d. per ton at the pit-mouth, still this fuel has cost between 5s. and 6s. per ton to get, and it represents a cost of between [redacted]

demanded of them, when it invariably happens that the boilers have to be forced to do the work. This is obviously a very bad policy, for it not only does harm to the boilers, but it also results in waste of fuel, owing to the fuel not being efficiently consumed; and a large percentage is wasted with the ashes, on account of the too frequent cleaning and poking of the fires.

As pointed out in the Report of the Royal Commission on Coal-supplies of 1905, collieries are extremely wasteful in the consumption of coal, no doubt to a large extent because the fuel used is generally of inferior quality and of small value. It is also pointed out in the same report that if the whole of the plant of the collieries in the United Kingdom were modern plants of the best description the consumption of coal would be only about one half of what it is to-day.

One of the principal sources of loss at a colliery may be the large number of wasteful and decrepit auxiliary-engines which are at work at considerable distances from the boiler-plant; and, although the boiler-plant itself may be good, still the colliery-consumption is high, owing more to the state of the machinery than to the inefficiency of the boilers. It is, therefore, obvious that, where such circumstances exist, the first step towards a remedy is to overhaul the steam-cylinders and valves, and to see that the steam-pipes and joints are covered and maintained.

The tendency at the present time is to instal boilers to work at from three to five times the working pressure that was in vogue 20 or 30 years ago, and also to superheat the steam, thus obtaining drier steam at the engines and consequently a higher efficiency.

Since high-pressure steam has been introduced for colliery-work, water-tube boilers of two or three wellknown types are beginning to have consideration for colliery purposes. It is found that the water-tube type of boiler is, besides being safer than the Lancashire, more economical for even intermittent engines (such as the winding-engine), as the generation of steam is more rapid than is the case with the Lancashire boiler: consequently, less steam-reserve is required, and there is less waste by radiation. But it is also found that, owing to the large number of tubes and small parts connected with the water-tube type of boiler, where sedimentation and incrustation are liable

to take place, some form of water-softening plant must be installed also, where the water is hard. The initial outlay is consequently heavy, and thus the water-tube boiler is unfortunately still inaccessible to many.

Table I. illustrates the comparative efficiency of various types of boilers employed at some collieries in this district.

TABLE I.—EFFICIENCIES OF EGG-ENDED, LANCASHIRE AND STIRLING BOILERS.

Type of Boiler.	Dimensions.		Mean Steam-pressure per Square Foot.	Approximate Water-evaporation per Hour.	Approximate Capacity of Boiler.*	Temperature of Feed-water.	Approximate Efficiency.	Grate-area.	Heating Surface.	Water evaporated per Pound of Coal.
	Length.	Diameter.								
	Feet.	Feet.	Pounds.	Pounds.	Horse-power.	Degrees Fahr.	Per Cent.	Square Feet.	Square Feet.	Pounds.
Egg-ended ...	35	5	43	2,295	57·4	70	34·0	24	210	2·94
Lancashire ...	30	8	132	4,700	117·5	70	62·5	36	1,150	5·40
Stirling Water-tube	...	...	129	5,450	136·0	70	63·0	36	1,725	5·40

* Forty pounds of steam are taken as the equivalent of 1 horsepower.

The Stirling boiler was installed to drive a three-phase 50 cycles, 650 volts, alternating-current generator of 150 kilowatts. There are three upper steam-drums and one lower or mud-drum connected by three sets or banks of tubes $3\frac{1}{4}$ inches in diameter. The tubes are slightly curved near the ends, so as to allow them to enter the drums normally; and to provide for the free expansion and contraction of the boiler. The tubes are very tightly ex-

[redacted]

In considering this question of the type of high-pressure boiler best suited for colliery purposes, the writer is of opinion that for colliery winding and steam-driven hauling-engines, running intermittently, the Lancashire boiler has a good deal to recommend it, apart from economy. But, for continuously-running engines of the high-speed type, to work at a pressure of, say, 150 pounds and upwards per square inch, the water-tube boiler is the ideal type, on account of its higher efficiency and the enhanced safety.

An important consideration is the maintenance of the maximum boiler-pressure over a good term of years. If an engine be designed, and will give the best results at a pressure of, say, 150 pounds per square inch, there would be a serious loss of efficiency if the working pressure of the boiler-plant must be reduced, on account of indications of weakness in the plant. In the cylindrical type of boiler, it is not advisable to rely upon the maintenance of the working pressure for which it was originally built, for more than 10 to 15 years, on account of the deterioration of the shell-plates, unless the feed-water is very good or is treated for hardness, if it is not naturally a good boiler-water.

In the case of a water-tube boiler, it is, the writer believes, possible to maintain the maximum working pressure for a much longer term of years than is the case with a Lancashire boiler, as the defect of any tube or tubes can be remedied by replacements at a reasonable cost, and within a short space of time. Water-tube boilers are now almost invariably adopted for electric power-stations, other than for colliery-work, and their installation has yielded most satisfactory results. It is thus equally advisable that this type of boiler should be installed at collieries where high-speed engines are employed.

As to the comparative advantages or disadvantages of one or two types of water-tube boilers, the following points are prominent, namely:—

(1) It is the writer's opinion that there is not much, if any, difference in the efficiency of steam-generation by having the tubes inclined from the horizontal position, as in the Babcock-and-Wilcox type of boiler, or in the vertical position, as in the Thornycroft, Fleming, Ferguson or Stirling boiler.

(2) For the horizontal-tube type of boiler, it is claimed that, as the tubes are slightly inclined, the water and steam have a more natural circulation, the gases meet the tubes at right angles and being thus disseminated give the maximum amount of heat to the water. Whereas, in the case of the vertical-tube type of boiler, the gases, travelling at the same angle as the tubes are placed, do not strike the tubes so effectually, although the gases have a longer distance to travel and to give out their heat. Further, in the horizontal-tube type of boiler, dust is liable to accumulate on the tubes. This, as is wellknown, is a bad conductor of heat, thus causing reduction of efficiency; but, in the case of the vertical-tube type of boiler, the dust falls off the tubes and does not so readily adhere to them. In the Lancashire boiler, dust accumulates in the flues to a great extent, and cannot readily be removed.

(3) The horizontal-tube type of boiler is, owing to the tubes being straight and more accessible, the easiest to clean, and the tubes also are more readily changed or replaced. The maintenance and repair of water-tube boilers are undoubtedly more costly than with Lancashire boilers, as the tubes and drums must be kept clean, else the boiler soon loses efficiency, and this operation requires the labour of two men for about three days per boiler.

(4) Water-tube boilers are certainly safe as regards liability to explosion. This is a special feature in their favour, the only part that is liable to burst being the tubes, and when they do

[redacted]

cent. He thought that $1\frac{1}{2}$ per cent. could only be attained under the most favourable conditions, and, it was, he believed, the minimum yet reached at any colliery.

Mr. ALEXANDER SMITH said it was somewhat refreshing to hear colliery managers advocating economy in fuel, and impressed one with the change that had taken place since the days when no consideration was paid to the large quantities of coal consumed at collieries. From a long experience, he favoured Lancashire boilers for use at collieries. A Staffordshire engineer of considerable repute had declared that a plain egg-ended cylindrical boiler could be set in such a way, that the results would compare favourably with those obtained from Lancashire or water-tube boilers; but he (Mr. Smith) did not agree with that statement. He was surprised at the little difference of useful effect shown in the experiments or tests, between the Lancashire and the Stirling boiler. With only those results, and taking into consideration the lower capital-outlay, the difficulties from bad water, and the facility for cleaning and burning inferior fuel, the advantages seemed to be with the Lancashire boiler. He knew a case where the tubes of a Babcock-and-Wilcox boiler had been burnt through at one end in a comparatively short time, owing to the use of a cleaner that was too short and wedged the deposit at this end. There were cases where the use of water-tube boilers was advantageous, because of the small space that they occupied compared with their power; and, given the essential conditions of good water, good fuel and good stoking and attention, the results were good. For a colliery, however, where all these conditions did not prevail (and this was evident in Mr. Swallow's case, for his Lancashire and water-tube boilers did not give the evaporation that they ought to have done), the Lancashire boiler took a lot of beating.

Mr. S. L. THACKER said that the relative economy of types of boilers was by no means the only consideration; and an important question to decide was whether the initial cost and maintenance of the water-tube boiler would be repaid by the given percentage of saving in colliery-consumption on the colliery-output. He thought that the fuel consumed for colliery purposes was, in many instances, a bye-product of the working of the colliery, and not altogether a marketable one. Also he

thought that it was not correct to base the estimated saving on the average cost of production of the coal at the pit-mouth, as it should rather be based on the selling price of the fuel used. He agreed with Mr. Smith's remarks as to the relative merits of Lancashire and water-tube boilers. A good feature of the water-tube boiler was the saving of floor-space by the high capacity obtained in one given unit; in the case of the Walsall generating-station, 12,000 pounds of water were evaporated per hour from single units. He did not altogether agree with Mr. Swallow's statement that the changing of the tubes did not require skilled labour, as he thought that the work of replacement, expanding of ends, etc., required a higher degree of mechanical skill than was usually possessed by the average labourer. The inside of the tubes in the boilers of the Walsall power-station were cleaned by means of rotating scrapers driven by a small water-turbine.

Mr. H. C. PEAKE said that he had taken great interest in Mr. Swallow's paper, as he was making experiments with a Lancashire boiler. He was inclined to favour the Lancashire type of boiler for colliery purposes, because of the large reserve of contained water to draw upon. His experiments had been rather rough-and-ready, the water evaporated being measured from marks made on the water-gauge. The experiments were made with a Cornish boiler, put down about 30 years ago, with a chimney, 60 feet high; with good stoking and good fuel he had obtained an evaporation of 10 pounds of water with a consump-

[redacted]

accumulated in the boiler-flues, and whether the water-evaporation per pound of fuel of the water-tube boiler had diminished since the tests, referred to in the table, were made.

Mr. F. C. Swallow said that the consumption of $1\frac{1}{2}$ per cent. mentioned in his paper referred to two or three special collieries in the counties of Derbyshire, Durham and Northumberland. Water-tube boilers were much more costly to maintain; thus, at a colliery in South Wales, with 16 boilers, the cost of maintenance was, on an average, £27 19s. per boiler per annum. He had found that a man of the labouring class, a little above the average, with a little instruction, was able to keep the boilers in efficient repair. Very much could be achieved by good stoking; but, if mechanical stoking were employed, the stoking difficulties would be removed. The value of slack in South Staffordshire was about 2s. 6d. per ton, but in Northumberland and Durham, it was much more valuable, almost as high as the value of coal. In South Wales, it was more valuable than in South Staffordshire, steam-coal slack being worth 7s. per ton at the pit-mouth. The class of fuel used in the boilers under review was ordinary pit-slack.

Mr. F. A. Grayston proposed a vote of thanks to Mr. Swallow for his valuable paper.

Mr. Alexander Smith, in seconding the resolution, said that the members were particularly obliged to Mr. Swallow, as such a paper brought out the experiences of other colliery managers and conduced to ample discussion.

Mr. S. L. Thacker read the following notes on "Walsall Corporation Electric Supply":—

WALSALL CORPORATION ELECTRIC SUPPLY.

By S. L. THACKER.

Introduction.

The history of the electric-lighting movement in Walsall extends as far back as 1882, when a public company obtained powers under the Electric Lighting Acts for supplying current; but nothing was done, and the powers consequently lapsed.

In 1890, the Corporation applied for and obtained a Provisional Order, and retained Mr. Frederick Brown as their consulting engineer. Mr. Brown prepared a scheme in 1891, and, after a visit to America in connection with the South Staffordshire tramways, his report was laid before the Council in 1892, tenders were obtained in 1893, and powers were granted by the Local Government Board for a loan of £22,000 in 1894, the works being opened in 1895.

The boundaries of the area to be supplied necessitated a high-tension system of distribution, and Mr. Brown advised the adoption of what is known as the "Oxford" system: the continuous current generated at 2,000 volts being distributed by high-tension mains to rotary transformers, which supply the [redacted]

Description of the Plant.

Boiler-house.—As already mentioned, the first plant installed consisted of two Lancashire boilers, 30 feet long and 7½ feet in diameter, without cross-tubes, each having an evaporative capacity of 6,000 pounds of water per hour from and at 212° Fahr. These have been since supplemented by two Babcock-and-Wilcox water-tube boilers, each having a capacity of 6,000 pounds of water per hour; and two more Babcock-and-Wilcox boilers, each having a capacity of 12,000 pounds of water per hour: the two latter being supplied with superheaters in the boiler-flues. There is also in process of installation a Stirling water-tube boiler, equal to 12,000 pounds of water per hour, bringing the total boiler-capacity up to about 2,500 horsepower. The main flue from the boilers passes to a chimney-stack, 150 feet high and 5 feet in internal diameter.

Two Worthington duplex pumps and two Weir pumps supply feed-water to these boilers, and a Brown-Berryman feed-water heater was installed as part of the original plant. In this type of heater the steam circulates through coils of tubes and the water outside: any deposit falling into a mud-drum at the bottom. This heater has since been supplemented by a Green economizer, with 320 tubes and the usual scrapers, driven by an electromotor. The drop in temperature of the flue-gases passing through the economizer rendered it necessary to supplement the draught by a Chandler exhaust-fan, 7½ feet in diameter, running at 320 revolutions per minute. A bye-pass flue is provided, so that when the economizer is not at work the gases may pass direct to the chimney-stack. The boiler-house also contains a surface-condenser, with air and circulating pumps driven by a vertical engine.

Engine-house.—The original plant consisted of three Parker two-pole continuous-current generators of 80 kilowatts capacity at 2,000 volts, direct-coupled to Bumstead-and-Chandler engines of 120 horsepower, running at 350 revolutions per minute, and these were afterwards supplemented by two exactly similar sets, each of 180 kilowatts. The engines of these generators are single-acting compound-tandem, with splash-lubrication and flywheel governors, the two smaller ones having two cranks and the larger ones three cranks. Upon a supply of current

being required for the tramways, two further four-pole generators were installed, each of 350 kilowatts capacity, and coupled to Chandler engines: these being double-acting compound-tandem, with three cranks and forced lubrication. The whole of these engines have piston-valves driven, in the case of the smaller engines, by eccentrics and in the larger sets by a rocking lever from the crank-pin end of the connecting rod.

The armatures of the generators are wound on the Eickemeyer system, specialized by Messrs. Thomas Parker, Limited, by which each section is separately wound on a former and insulated before being put in position. This method, with modifications, has been adopted by other makers, and is of considerable importance in high-voltage machines, for, while ensuring the highest armature insulation, it facilitates repairs in the event of a burn-out. The generators are separately excited from a current at 110 volts, supplied by four small exciter-sets, which also provide current for the station and workshop motors and station-lighting. At the present time, a Parker generator of 400 kilowatts capacity, coupled to a Belliss-and-Morcom compound double-acting engine, with three cranks, is being installed.

Switchboard.—The switchboard is divided into two sections, the old section on a wooden frame with wide slate-panels, and the new section on a completely fire-proof frame, with narrow panels, necessitating the use of edge-reading instruments.

Cables.—The original high-tension feeders were concentric indiarubber-insulated cables, drawn through iron pipes. Subsequent cables, both high and low tension, were all of the Callender bitumen-insulated type, laid in cast-iron and wooden troughs, and filled in with bitumen. The latest feeders are Callender paper-insulated and lead-sheathed cables laid solid in the same way.

METHOD OF WORKING.

There are two separate sets of central-station omnibus-bars for lighting and traction, which, however, can be paralleled by a suitable switch, and all the generators with the exception of Nos. 1 and 2 have change-over switches, by which they can be connected to either set of bars. The starting of transformers, and their control and regulation, is carried out from the central station, and for the purpose of this description the writer has selected one generator and one transformer to illustrate the method, eliminating a few minor connections to avoid confusion.

Fig. 1 (Plate XV.) is a diagrammatic sketch of the connections for one generator-panel of the switchboard. Current is supplied from the exciters to the low-tension omnibus-bars at 110 volts, and thence to the generator-field coils, G-F, passing through a single-pole switch, S, and a regulating-rheostat, R-R. This resistance is used to regulate the excitation of the generator-fields, and thus the electromotive force of the high-tension current. Normally, the switch is in the position, S_1; but, upon taking any generator off the supply, the switch is thrown over to the position S_2, thereby short-circuiting the generator-fields, and absorbing the self-induction. The leads from the generator-commutator, G-C, are taken to the high-tension double-pole switch, HS, the current passing through the coils of the magnetic cut-out, M-C, and thence through the ammeter, A, to the high-tension omnibus-bars. S-C is the shunt-coil of the magnetic cut-out, it is connected across the low-tension exciter omnibus-bars to bring out the high-tension switch in the event of a reversal of the main current.

Fig. 2 (Plate XV.) is a similar diagram of the connections of one transformer-panel of the main switchboard, and Fig. 3 is a diagram of the switch-connections at a sub-station.

Leads from the high-tension omnibus-bars are connected

through an ammeter, A, and the coils of the magnetic cut-out, M-C (Fig. 2), to a double-pole high-tension switch, HS, exactly similar to the generator-switch, and from this switch the transformer feeders, T-F, pass out to the sub-station: a rheostat, R-R, being inserted in the positive feeder for starting and regulating purposes. One pair of feeders runs from each transformer-panel in the main station to each transformer located in the sub-stations. Pilot-wires, P-W, run back from the low-tension side of each transformer to a voltmeter, V, in the main station, and a short-circuit switch, S-CS, is placed across each pair of pilot-wires, the use of which will be explained shortly.

Referring now to the sub-station diagram (Fig. 3), each transformer is a double-pole motor-generator with an armature having a high-tension and a low-tension winding and high-tension and low-tension commutators, H-TC and L-TC. The fields are excited by low-tension shunt-coils, but they also have a high-tension winding in series with the high-tension armature winding. For the purpose of illustration, the two windings are shown separately.

Upon closing the high-tension starting switch in the main station, HS (Fig. 2), current at 2,000 volts comes in by the feeders, T-F, and passes round the series-field winding, Sr-F, and through the high-tension winding of the armature. This starts the transformer as a series motor, and, as the machine gets up speed, the low-tension voltage rises and is indicated at the main [redacted]

which opens this switch in the event of an excess of current. The long-range switch, L-RS, has a ratchet-and-pawl movement, and is so arranged that the succeeding short-circuiting of the pilot-wires will bring out the switch; and, to take a transformer off the circuit, the whole operation is categorically reversed.

In conclusion, the author tenders his thanks to Mr. Alexander Wyllie, the resident engineer, and to Mr. R. G. Pratt, one of the station-engineers, for their courtesy and for the information furnished for the purposes of this paper.

Mr. Arthur Sopwith asked what was the variation of the load. Of course, for municipal work, the running of tramways and lighting, it was an easy matter to foresee the load, and if not known beforehand it was soon determined in practice; but at mines, they had to deal with extreme variations of the load.

Mr. S. L. Thacker replied that the variation of the load was considerable, but it was usually a gradual one. There was no sudden fluctuation of the load, such as they would be likely to get at mines, owing to the jamming of coal-cutters, etc. The day-load was light, and it was then possible to shut down the generating plant and run from the batteries. As the load increased, the various units were put on to supply, until the maximum period was reached from 5 to 8·30 p.m.

The President (Mr. F. A. Grayston), in proposing a vote of thanks to Mr. Thacker, said that the members were extremely obliged to him for his paper.

Mr. Alexander Smith seconded the resolution, which was unanimously approved.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

GENERAL MEETING,

HELD AT THE TECHNICAL COLLEGE, DERBY, DECEMBER 8TH, 1906.

MR. G. J. BINNS, VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—

Mr. JABEZ EMMERSON, Colliery Manager, Bagworth, near Leicester.
Mr. FRANK P. RUDDER, Engineer, 10, Madeley Street, Derby.
Mr. JOHN THOMPSON, Manager's Assistant, 20, Birch Villas, Netherthorpe, Staveley, Chesterfield.

ASSOCIATES—

Mr. SIDNEY BERNARD GALPIN, Miner, Fern Villas, Gilt Hill, Kimberley, Nottinghamshire.
Mr. DAVID MÔNDEY, Electrical Engineer, Rosemary Street, Mansfield.

[redacted]

quarry); and (*c*) by a system in which the fire is placed in the compressed air. This system (Fig. 1) was invented by Mr. David Bannister, employed by Messrs. Crawshaw and Warburton, Limited, Dewsbury. The compressed air is led into a chamber, *a*, sufficiently large to hold a good-sized lamp, and admission is obtained through a man-hole, *b*. The stove-lamp, *c*, with three

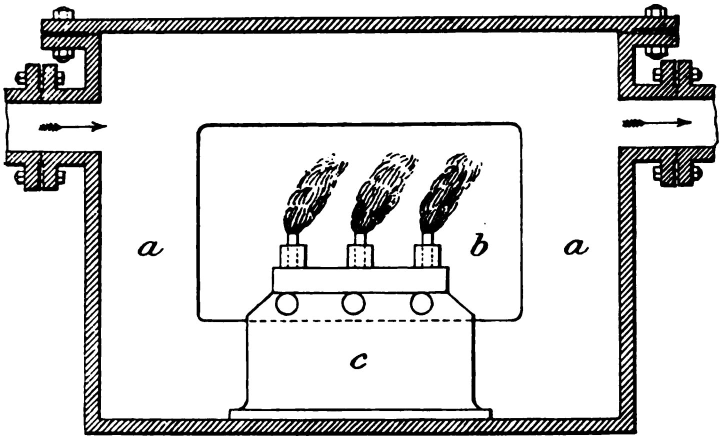

FIG. 1.—BANNISTER AIR-HEATER.

burners (3 inches wide) has an oil-capacity to burn for 24 hours or longer. This lamp is lighted and secured air-tight inside the chamber, whilst the air, under pressure, supporting the combustion, flows through and is heated by the lamp. The lamp is placed sufficiently low down in the chamber so as to allow of its burning freely and to prevent it from being blown out. The appliance could be amplified by arranging that the lamp could be adjusted from the outside and oil pumped into the lamp, so that the casing need seldom be opened. A Bannister apparatus has been working for 5 years, in everyday work, at Messrs. Crawshaw and Warburton's Dewsbury collieries; and another installation has been recently erected. For simplicity and efficiency, this appliance commands the attention of users of compressed air; and every credit is due to Mr. Bannister, the inventor.

(2) Taking Mr. Piggford's data as to his second source of efficiency, namely, the adoption of two-stage air-compression, he (Mr. Abell) noted that the air is compressed to 25 pounds per square inch in the first stage, and to 60 pounds per square inch in the second stage. It will be recognized that thermal

efficiency can be increased by an expenditure of capital that cannot be warranted; hence the question arises, at what pressure, by stage-compression, is the greatest commercial efficiency obtained? In other words, scientifically, an isothermal curve is required; whilst for commercial efficiency, a blend of the isothermal and adiabatic curves is required. With large air-compressors, from which Mr. Piggford has derived certain data, it is commercially sound to use two-stage air-compressors for a final pressure of 60 pounds per square inch, so as to pass the air through an intercooler when it leaves the low-pressure cylinder, thereby cooling it down to atmospheric temperature and reducing the volume of air in course of compression. On the other hand, two-stage air-compression costs in capital outlay more money for a given power. However, if the power be large, the cost of two-stage air-compression is justified; but it is not if the power be small. In large air-compressors, such

TABLE I.—COMPARISON OF SINGLE-STAGE AND TWO-STAGE AIR-COMPRESSORS.

(a) Single-stage Air-compressor.			(b) Two-stage Air-compressor.		
Delivery-pressures of Air per Square Inch.	Temperatures of Air.		Delivery-pressure of Air per Square Inch.	Temperatures of Air.	
	Adiabatic or Theoretical Compression.	Probable.		Adiabatic or Theoretical Compression.	Probable.
Pounds.	Degrees Fahr.	Degrees Fahr.	Pounds.	Degrees Fahr.	Degrees Fahr.
30	258	120	80	433	160
60	374	180	160	529	220

as the one under consideration, the volume of air in relation to [redacted]

cial value under the abovementioned conditions, that is a blend between the adiabatic and the isothermal curves. The temperatures with two-stage air-compression recorded in Table I. ought to be obtained with good jacketing, but without the use of after-coolers. They probably would not represent average practice, with long-stroke air-compressors presenting large cylinder-areas, where the cooling is not so effective as in smaller machines; and, to cover this, it is safe to add 20° to 30° Fahr. to the temperatures.

(3) In Riedler and Sturgeon air-compressors, the volumetric efficiency is high, as clearances have been reduced, and the old bye-pass arrangement has, in many cases, been forgotten. At the same time, he (Mr. Abell) had seen many large air-compressors in which the clearances were large, and the bye-pass would very materially increase their efficiency. In some instances, he (Mr. Abell) had seen simple short grooves cut at either end of the air-cylinder, so that the compressed air conveyed from the delivery to the suction-side at the end of every stroke raised the volumetric efficiency to 90 per cent. of the theoretical efficiency.

The Chairman (Mr. G. J. Binns) said that he anticipated that Mr. Stokes would have something to say with regard to the suggested placing of a paraffin lamp close to the coal-cutter.

Mr. A. H. Stokes (H.M. Inspector of Mines) thought that the objections to the use of a paraffin lamp were so patent to everybody present that it was unnecessary for him to call attention to them.

The Chairman (Mr. G. J. Binns) said that mining engineers had been anxious to remove lights right away from compressed-air receivers. There had been cases in which lights had got into receivers and played havoc with the hydrocarbons deposited there. These matters required careful consideration, and although the suggestion seemed to indicate a simple and efficacious way of increasing the power of compressed-air plant, there might be reasons which would make the members hesitate before adopting the Bannister system.

Mr. W. Price Abell maintained that the use of enclosed lamps was incomparably safer than the open naked fires now in

use, and which were rendered unnecessary by Mr. Bannister's arrangement. Mr. Bannister had devised his arrangement to avoid the use of naked fires as a surer means of safety than the open fires used by Mr. Piggford at the Teversal collieries.

DISCUSSION OF MESSRS. W. N. ATKINSON AND A. M. HENSHAW'S PAPER ON "THE COURRIÈRES EXPLOSION."*

Mr. A. H. Stokes (H.M. Inspector of Mines) said that he was sure that there was one point upon which everyone in that room would agree with him, and that was in an expression of sorrow for the poor fellows who had lost their lives, and of sympathy for that still larger number of people whose bread-winners had been taken from them. As a body of engineers, they would concur with him in recording their sympathy in connection with the greatest mining catastrophe that the world had ever known. Members who had read the paper under discussion would see at once how difficult it had been to find out the initial cause of the explosion; and, lamentable as the loss of life had been, he thought that they were less interested in discussing the number of deaths than in finding out what was the cause. The members should next consider what precautionary measures ought to be taken to prevent a catastrophe of a similar nature—though probably never so big—in this country. The number of deaths [redacted]

in which it occurred? Members who had been so unfortunate as to be present after a big explosion would know that sometimes one part of the mine had received the full force of its power; while in another part, ventilated by a distinct and separate split, men had continued at work without knowing that anything had occurred. Surely that brought home to them the value of having the districts so split up by ventilation that any catastrophe which occurred would, so far as possible, be isolated. That was one lesson to be learned from this terrible catastrophe. They would also notice from the paper how difficult it was to say where the explosion originated. The writers stated that, after several inspections and the closest consideration of all the circumstances, the most probable explanation which suggested itself was that a shot had miss-fired on the previous day, and that at the time of the explosion the men were engaged in cutting it out. The writers allege that it was the only feasible explanation to which they could come; but, if the shot had missed fire on the previous day, it was strange that some of the officials should not have known and recorded it, for the men, he presumed, would go out and not work in a place where there was a miss-fired shot and a tape-fuse had been used for firing it. All the officials were killed, and it was impossible to say whether the miss-fire had been reported verbally to them or not. He (Mr. Stokes) understood that similar holes had been found before and since the explosion. There was another difficulty which the writers of the paper had felt: the heading was rather large in sectional area, and the shot must not only have been a blown-out shot, but the flame must have travelled 30 feet before it struck the dust lying on the floor and raised it into flame. Let the members try and imagine a flame travelling 30 feet and then striking and igniting the dust; let them further bear in mind that this dust was not the fine flour found in main roadways; but that it was lying in a new clean heading that was being driven daily.

There appeared to be one explanation with respect to the origin of the explosion which the writers did not entertain or discuss, namely:—The possibility of the fourth man in the Lecœuvre heading being engaged, on the top of the fourth air-pipe, in handling the explosives, or manipulating a charge, and that this had exploded and caused the extensive shattering of the pipe. In support of this suggestion, there were the facts

that the man's leg and arm were blown from his body and found 9 feet away, and that the air-pipe was broken into numerous fragments. The air-pipes, lying on the floor, formed an easy place to rest the explosives upon the top; the distance from the face would make it a likely place for dust to be found on the floor due to the filling of tubs; and the explosive, if so fired, would be placed almost in contact with the dust and have every opportunity of igniting it. It was the fourth air-pipe that was so shattered into small fragments. The adjoining pipes were bent and little broken. The man may have been taking apart either the actually recovered charge (if there had been a miss-fire) or in some other way handling the explosive. The fourth air-pipe had been blown into a large number of small pieces; and this effect might be expected if a high explosive had been exploded upon it.

In considering this suggestion, many things appeared to support such a theory, whereas the cutting out of a miss-fired shot and striking the detonator was surrounded by many improbabilities, not the least being that similar holes had been observed before and since; the long distance, 30 feet, that the flame would have to travel before it struck the dust on the floor, whereas in the experimental gallery at Frameries, with a similar charge and under similar conditions, the flame was observed to travel only 6 feet (No. 1 experiment). Nos. 7 and 8 experiments were made under artificial conditions, which did not exist in the Lecœuvre heading at the time of the explosion. He (Mr. Stokes), however, agreed with the writers that probably "the

[redacted]

Mr. WILLIAM MAURICE (Hucknall Torkard) said that every member would join with Mr. Stokes in expressing their sympathy in the warmest possible manner with all those who had suffered in any way by this terrible catastrophe. There were one or two points suggested to him, partly by the paper under discussion and partly by the official report* on the Courrières explosion:—(1) Whether the time had not arrived for the members to revise their ideas on the subject of dust explosions, and (2) whether the treatment of dust by water was not more in the nature of a pretence than a genuine contribution to the safety of mines. He (Mr. Maurice) gathered from the general trend of published statements that coal-dust was considered the only explosive dust to be found in a mine, and that watering or otherwise preventing the accumulation of dry coal-dust was the only satisfactory method of preventing dust-explosions. Holding the view that gases were not actually explosive, except when mixed with air or oxygen, and then only when the mixture was in certain definite proportions, he regarded it as an established fact that any kind of dust in a state of suspension might act as a substitute for air or oxygen and so render explosive any medium in which it might be suspended. If that were so, it seemed to him to be rather disturbing to generally accepted views. He (Mr. Maurice) did not believe that any system of watering now in use really touched the dangerous dust to any appreciable extent, and he ventured to think that just as the enclosure of explosives in water for safety had given way to improvements in the explosives themselves, so would the analogous treatment of coal-dust fall back before other and better methods.

Mr. L. W. DE GRAVE (Derby) said that when he visited the Courrières collieries he was much struck with the fact that the whole of the workings were interconnected. It was probable that the cause of the explosion would never be known for certain. A blown-out shot, in the presence of finely divided coal-dust, would, of course, be sufficient, but he understood from Mr. Stokes' remarks that the nearest dust was said to be 30 feet distant. The detonation of hydrocarbons would generate gas, which, under certain conditions, could be ignited; but without

* *Report to H.M. Secretary of State for the Home Department on the Disaster which occurred at Courrières Mine, Pas de Calais, France, on March 10th, 1906*, by Messrs. H. Cunynghame and W. N. Atkinson, 1906 [3171].

having had further opportunities of studying the paper he did not care to advance a theory.

Mr. CHARLES CHANDLEY (Nottingham) inquired whether the stoppings built round the fire were found intact, or if not, in which direction they were blown out; and he suggested that there might have been a leakage of carbon monoxide at the stoppings.

Mr. BENJAMIN MCLAREN said that the fire had been enclosed by means of stoppings, which were completed on the night before the explosion. Of the five stoppings on the return side, Nos. 1, 4 and 5 were found intact, and Nos. 2 and 3, which were simply brick walls, instead of being blown outwards, as they would have been had the fire caused the explosion, were blown inwards towards the fire.

Mr. J. MEIN (South Normanton) remarked that it came out with startling clearness that there was either no gas present in connection with the explosion, or that (if present) it was infinitesimal in quantity. He thought that the balance of probability was that there was no gas. After three months, although the ventilation had been suspended, they could not find a trace of gas even with the hydrogen-flame test. Holes had also been drilled into the coal, and not the slightest trace of gas had been found. That was one of the most startling features in connection with this sad affair, and it had impressed him very much. He believed that some members, who had been practising their pro-

[redacted]

removed and another put into its place, and if there had been any number of bad detonators, they could have been removed with safety, until the shot had been fired. If the conclusions of the writers were correct, namely, that the explosion was caused by an accidentally-fired detonator which had been left in a missed shot, then it clearly followed that if this tube-arrangement had been employed, the Courrières disaster would have been avoided.

Mr. A. H. Stokes asked where this arrangement was in use.

Mr. Mein replied that many good things were not in use now, and that they would be in use before members were very much older.

Mr. A. H. Stokes said his only reply was that he hoped that the use of the detonator-appliance, just described, would be deferred for a few years.

Mr. G. H. Ashwin (Sheffield) said that he was not sure whether he understood Mr. Maurice correctly; but he thought that he expressed the view that watering the roads in the mine would not be an effective way of dealing with the dust-difficulty. If that were so, he would remind Mr. Maurice that the evidence given in an enquiry into a colliery explosion in South Wales a short time ago proved that the explosion was practically confined to one part of the pit, because efficient watering was in operation.

Mr. W. Maurice was afraid that he had not made himself sufficiently clear on the question of watering. He agreed that a thorough wetting of the area, in the vicinity of a shot-hole, for example, might be contributory to safety, but it was not local watering that he had in mind. He was thinking of systematic attempts to render mine-air humid. These he regarded as failures, but he admitted that spraying appliances were useful for keeping roads in good order or for watering local areas.

Mr. G. Spencer (West Hallam) thought that the only inference to be drawn from the paper was that coal-dust was the most fruitful source of explosions. Whatever might be the origin (a blown-out shot or otherwise) it was particularly necessary to remove as far as possible the dust-danger. Several thousand pounds had been expended at a large colliery in providing what was expected to be an efficient water-spraying appliance, and it had proved a failure. Instead of expending a large sum on

such plant, he (Mr. Spencer) believed that a moderate expenditure would provide an apparatus on the vacuum-cleaning principle, which could be applied to removing the dust from the roof and sides of roads.

Mr. A. H. Stokes remarked that two or three speakers had been discussing the question of dust generally; what they had to consider in this case, however, was not the firing of a shot on a main roadway, which had been in use for 20 or 30 years; but, taking the paper as affording a correct explanation, a shot fired in a new heading, which had a clean face day by day. Then the question arose whether coal-headings should be watered every time that a shot was fired. Such regulations were necessary when shots were fired in a main roadway, where the dust was thick and like flour, but he wanted the members to consider the place where this explosion was supposed to have occurred, a heading, which was being continued daily, where they could not expect to find anything like the dust that they met with in a roadway.

Mr. P. Beaumont (Church Gresley) said that the Courrières explosion raised the question of detonation. He thought that the evidence rather opposed the idea of an explosion originating from carbon monoxide as suggested by Mr. C. Chandley; and he ventured to suggest that it was not flame or heat but detonation which fired the dust. He believed it was possible that a sudden detonation could produce such effects in the form of air-vibrations that a certain mixture of air and coal-dust, becoming [redacted]

than that specified for the purpose. Would it not be possible for experiments to be made with powerful detonators alone, to see whether similar results could not be obtained in that way? It was obvious that no amount of watering in the Courrières collieries would have prevented that shot, although he agreed that if certain safety-zones had been actually laid off, it was probable that this enormous disaster would have been averted, or, at all events, restricted in area. It appeared advisable that a pit should be divided into districts, and if an explosion occurred, the effects might be thus limited to the smallest possible area.

Mr. C. CHANDLEY observed that the members were rather apt to look upon coal-dust as being required in very large quantities to form an explosive mixture. He would remind them, however, that 10,000 cubic feet of gas were produced from a ton of coal by destructive distillation. It required only a very small amount of coal-dust to be brought into contact with heat to be destructively distilled, and to produce a considerable volume of gas, which, with air, became an explosive mixture. The explosion of coal-dust differed, therefore, from the explosion of any other dust. In one case gas might be generated, while in the other there was merely rapid combustion. The liability to explosion of new coal-dust in a heading or stall due to the accidental application of heat was much more serious than that of old coal and other dust on the roads, and these facts supported what Mr. Stokes had been urging, that they must look to a serious change in the method of dealing with coal-dust at the face.

The CHAIRMAN (Mr. G. J. Binns) wished to associate himself very strongly with Mr. Stokes in the remarks that he had made as to their feelings of sympathy with everyone affected by this great disaster. At one time the Courrières collieries were famous throughout the world for the extreme safety of their method of working; and, the particulars being published,* many engineers had examined the methods of timbering, which had reduced the death-rate from falls of roof and side to a very considerable extent at the Courrières collieries. Some of the coal-seams were absolutely inverted, and the roof and floor were extremely crushed. The seam in which the explosion occurred must have been harder than one that he had examined, seeing that explo-

* *Mines and Quarries: General Report and Statistics for 1899*, page 74; and *Trans. Inst. M. E.*, 1900, vol. xx., page 164.

sives were in use. Mr. Stokes' remarks as to the isolation of districts were noteworthy, and the Courrières explosion rather controverted the contention sometimes made (not by H.M. inspectors of mines or mining engineers, or by colliery managers) by the labour party, that all pits should be connected and that shafts should be sunk every ¼ mile or so. Mr. Beaumont's remarks as to the possibility of the explosion being caused by detonation were extremely valuable. Mr. de Grave had made some experiments with detonators in gas; and he hoped that he would follow them up with similar experiments in dusty air, as the results might throw considerable light on a question which had now assumed the utmost importance.

The further discussion was adjourned.

DISCUSSION OF MR. C. LATHAM'S "NOTES ON THE DETECTION AND ESTIMATION OF INFLAMMABLE GASES IN MINES BY MEANS OF FLAME-CAPS."*

Mr. C. Chandley remarked that this paper had been treated somewhat lightly, and Mr. Latham had been rather chaffed about it; but, personally, he thought that Mr. Latham's position was unassailable. The paper did not seem to be introducing very much more than a plea for the use of various kinds of fire-damp detectors. So far as he knew, these detectors were found only in lamp-cabins, and they never heard of them [redacted]

atmosphere, or for protection in case of emergency? If the safety-lamp was used, generally speaking, to allow men to work in an explosive atmosphere, the members need not trouble about fire-damp detectors, as safety-lamps had their own limitations; but if they were to be used as precautionary or emergency-lamps only, he did not see how mining engineers could avoid the conclusion that the safety-lamp should be able to detect the smallest quantity of gas in the presence of dust, and therefore detectors should be used systematically. The logic of Mr. Latham's position seemed to be quite obvious, however disagreeable it might be.

Mr. Ashwin asked how a safety-lamp could burn in an explosive atmosphere?

Mr. H. R. Hewitt (H.M. Inspector of Mines) said that evidently Mr. Ashwin was referring to an atmosphere containing over 3 per cent. of fire-damp, in which case a test with a lamp capable of detecting a very small percentage would probably be dangerous. In any tests that were made, the ordinary safety-lamp reduced to a blue flame should be first tried, and, if gas was present, the object of making the test was accomplished. He (Mr. Hewitt) would like to see all return-airways tested for as low a percentage of fire-damp as 1. It was probable that there were hundreds of mines in this country where the return-airways would show 2 per cent. of fire-damp, which were now considered and reported as being free from gas, from the fact that none had been seen. He did not consider that a lamp or instrument for finding less than would an ordinary safety-lamp, should be placed in the charge of either a deputy or collier, but that the tests should be made by the manager or a capable assistant. He agreed with Mr. Latham that the terms "flameless" and "safe," as applied to explosives, were unfortunate in view of the three months' duration of the use of a permitted explosive where such a quantity of gas is found as to be "indicative of danger." He agreed with Mr. Latham that a much smaller quantity of gas than could be seen by an ordinary safety-lamp was "indicative of danger," and should be prepared for and its consequential results guarded against by stringent precautions.

The further discussion was adjourned.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
NOVEMBER 13TH, 1906.

MR. CHARLES PILKINGTON, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. FRANCIS VERRILL BROWN, Mechanical and Electrical Engineer, 49, Deansgate, Manchester.

Mr. WILLIAM LOWBRIDGE HOBBS, Mining Engineer, 100, Bolton Road, Pendleton, Manchester.

ASSOCIATE MEMBER—

Mr. JAMES CUNLIFFE, 81, Moor Road, Chorley.

DISCUSSION OF MR. W. McKAY'S PAPER ON "THE BOULTHAM WELL AT LINCOLN."*

[redacted]

was found at a depth of 955 feet below the surface. The first 3 inches of the boring, below the depth of 1,561 feet 3 inches, passed through New Red Sandstone. Since then, boring operations had been continued, but he did not know the exact depth. Salt had not been found in the boring.

Mr. Joseph Dickinson remarked that rock-salt overlaid the New Red Sandstone in Cheshire.

The President (Mr. Pilkington) said that, in sinking a bore-hole near Warrington, weak brine had been found at a depth of 100 feet; and, it being found that all the deeper bore-holes in the neighbourhood had salt in them, the boring was abandoned.

Mr. W. McKay said that, in the case of the Boultham well, it appeared that the salt had disappeared from this particular area, and that only layers of gypsum were left. In some parts of Lincolnshire, water had been found impregnated with salt; but, at Gainsborough, at a depth of 1,515 feet, splendid water had been found, and an equally good result was anticipated from the Boultham well.

The President (Mr. C. Pilkington) asked whether the supply of water was diminishing.

Mr. W. McKay replied that, on the contrary, it had increased at Gainsborough, from the time that it was tapped up to the present time. He believed, however, that it was taking the supply from other districts. On this assumption, Lincoln, being on the lower level, would, no doubt, take the water from other places.

The President (Mr. Charles Pilkington) delivered the following "Presidential Address":—

PRESIDENTIAL ADDRESS.

By CHARLES PILKINGTON.

It is customary for your President to deliver an address at the opening of the session. I am sorry that I cannot give you one on some geological subject: for this Society was primarily geological, and to the geologists we owe its foundation and its establishment as a successful and useful institution. Perhaps, if geologists read mining papers and miners read geological papers, the discussions would be more lively; but scientific men are so very severe in argument, not to say vicious in their search after truth, that I dare not adopt this suggestion, and so fall back on surer ground and briefly review some of the mining problems with which we are face to face.

All professions and trades change as time goes on, owing to new inventions and methods, but mining is subject to greater changes than most other businesses, and colliery-proprietors, mining engineers and officials, are well aware that, speaking generally, they must prepare themselves to meet great and increasing difficulties, for although there is plenty of coal left in this country, most of the easily-won seams are worked out; [redacted]

merable tracings, and where he has spent some four or five years in learning to use the miner's dial and to plot accurately. Now it is necessary that he should be taught discipline, if he has to learn to command, and it is necessary that he should be a competent surveyor; but it is not necessary that he should spend the best years of his apprenticeship, when his mind is most capable of receiving impressions, in learning to becoming a past master in the use of the dial. It is true that the pupil is occasionally sent to see some work carried out according to instructions; and, if he is fortunate, he may later on have charge of a pit in connection with and under a certificated manager for a month or so; but I think that a rather wider range should be given to him, if he is being educated to take the position of a colliery manager, should he prove to have grit enough to take it. He should know more of mechanical engineering than was formerly thought necessary, although he need not go into those technical details which are better left to the expert. He should be well grounded in electricity, and know something of building. The modern student has a great advantage over the man of the past, for he has the use of such excellent mining schools as those of Manchester and Wigan (speaking of this district only), equipped with every modern luxury in the way of capable teachers, good models and diagrams. But it is one thing to learn at a school and another to have knowledge ingrained into one's system by familiar use, and there are things which can be taught at a colliery far better than anywhere else. He should for instance, amongst other things, learn by personal experience something of the cost and nature of the materials that he uses and of the coals sent to the surface. Now, these were supposed to be more or less departmental secrets when I was young; and an inquisitive pupil was regarded with some suspicion. There are certain things that may have to be kept secret, but if you are educating a youngster, and want him to become useful, the more that you let him know the better. In saying this I do not suggest that the education of the surveyor should be neglected: far from it, I would give him the best facilities to learn his work, and better instruments to work with than are supplied at some collieries. I would not have him answer such an advertizement as appeared lately in a Yorkshire paper:—"Wanted a surveyor at a large colliery, 30s. a week." But the talents required for surveying and the

talents required for management are not the same, and may not be combined in the same individual. The very exactness of detail required from the surveyor might develop into a niggling habit of thought in a manager.

The first practical question to which I would call your attention is that of coal-cutting by machinery. There are some members who have given to this question their best thought and work, and have generously passed on to us the result of their labours; but the general frame of mind in the past has been too cautious and conservative. It is nearly thirty years since I first handled a coal-cutter underground, and yet how few comparatively were in use ten years ago. It is, to a certain extent, the fault of their makers and introducers, who in the past claimed for them far more than they could possibly achieve. Most of the early statements about cost and speed of cutting were absolutely unbusiness-like, and naturally caused hard-headed mining men to fight shy of trying the machines. But it is different now, for we have a fair amount of independent figures to go upon, not only giving the work done in a certain time, but the time required for preparing the places for the machines, the cost of repairs and management, the amount of breakdowns over a given period, and the capital outlay. There are some twenty or thirty different machines on the market worked by compressed air or electricity, so that we have a much larger choice than we originally had. This is very important, for one machine is suitable to work under one [redacted]

But, even under the most favourable circumstances, coal-cutting requires an immense amount of personal care, forethought and management; and few elderly men can adapt themselves to the work, as questions that are novel in themselves occur with vexatious frequency. The man who has charge of a district or mine, where cutting machines are used, should be bred young to the work, if possible; and there is no doubt that the managers, whom we are educating now, will be far more successful in this department than the elder men of the present day.

These remarks apply equally to underground coal-conveyors, which have received little attention up to the present time. They are successful enough, as far as the work done is concerned, but they are usually very cumbrous and expensive to move. A light, easily-driven and quickly-moved arrangement is wanted, but it is only half-invented at the present time.

New pits will generally have to be deeper than the old ones, and the problems of cheap and safe winding are many and difficult. The immense weight of 3,000 feet of winding-rope, and the full load at starting, together constitute a great difficulty. Many attempts, more or less successful, have been made to overcome it: some of the best, so far as balancing the load is concerned, fill the pit with ropes, each difficult to examine, and the breakage of one of which might cause inextricable confusion and long stoppage. It seems to me that the best solution is the conical-grooved drum of some modern design.

The great cost of the pits and machinery will make it necessary that one set of shafts shall serve a very large area, and consequently wind a large quantity of coal. Therefore the distance from the pit-bottom, at which work can be safely carried on, is now occupying attention; but an arbitrary limit, such as had been proposed, would, in many cases, put a colliery with deep pits in the Bankruptcy Court, and throw the colliers out of work. Safety is, of course, the important factor; and, when the limits are being approached, a very small area of workings worked at very high pressure, with improved ventilating machinery and large roads, may enable us to work with safety and health at great distances from the shaft.

To achieve the best result, ponies must be kept out of the

pit, and their places taken by hauling-engines driven by compressed air or electricity.

The use of coal-cutting machinery, at the far end, in a hot and distant district, driven by compressed air, will help to cool the atmosphere and to improve the ventilation. Here is a question for some member to work out: what is the best way of doing it? A long length of pipes direct from the surface is expensive to lay down and difficult to keep in order. Air-compressors, near the far end, driven by electricity, seem a plausible solution; but the heat developed at the compressor must be equal to the cold created at the face, so that there is no gain in temperature unless a small current of fresh air passes over the motor and air-compressor direct into the return-airway. I think that science may find in the future some means cheaper than the suggested use of liquid air to help us; but, in all these things, cheapness is an absolute necessity. The more power that we use in winning a ton of coal, the more it behoves us to economize the fuel which creates that power, and here we must turn for help to mechanical engineers. I know, by experience, that they are always ready, but let them see to it that they do not frighten us by excessive costs.

Greater depth means greater heat, and another enemy may have to be encountered. There are now mines in Great Britain hot enough to propagate the larvæ of *Ankylostoma*. Given a little dampness and the presence of one contaminated person, [redacted]

medical certificate being obtained stating that he is free from this disease. Any district where a case is known to exist should be declared an "infected district" under the Infectious Diseases Act, and miners going from that to another hot district should be required to produce a doctor's certificate that they are free from the malady. It has been found that ankylostomiasis is easily diagnosed by an examination of the blood; and the medical authorities of the different countries and other areas should appoint properly qualified men to detect the disease. There has been a case lately in Scotland; last year there was a case in Manchester; it is known that the disease exists in Cornwall; and it seems to me that the less time we lose in establishing national precautions the better. There can be no doubt that the workmen will endeavour to have this disease included amongst the accidents for which compensation is paid; but the worst aspect of the misfortune would be the suffering and annoyance caused to the men themselves.

This brings me naturally to the subject of sanitation. From time to time, a disturbance is made about the dirty condition of many of our pits, designs of earth-closets and pails are discussed, and rules are drafted and printed, but they are difficult to enforce. The subject is an unsavoury one, and when the management's conscience is appeased by providing the apparatus and posting the rules on the headgear, the subject is often allowed to slide into its old channel. It is a somewhat difficult question, and the education of the workmen, as well as the proprietors, into a proper frame of mind on the subject appears to be the most effectual way of dealing with it.

I now come to the dust question: one of the most important of the day. According to a recent report,* the great Courrières disaster was mostly, if not entirely, due to a dust-explosion. I do not think any of us wanted any more proofs of the dust danger; but we do need more experiments as to the best way of removing it, and the deeper and hotter the mine, the greater will be the difficulty. In new pits it may be easy to keep screening and sorting arrangements at some distance from and, if pos-

* *Report to H.M. Secretary of State for the Home Department on the Disaster which occurred at Courrières Mine, Pas de Calais, France, on March 10th, 1906*, by Messrs. H. Cunynghame and W. N. Atkinson, 1906 [Cd. 3171].

sible, on the north-east (or opposite side to the prevailing wind) of the downcast pit, so as to prevent the dust from descending. But we are still face to face with the dust created in the mine, and it must be remembered, where mechanical haulage is used, that the dust of the main wagon-roads, although less in quantity, is much more dangerous than it used to be, when ponies pulverized the warrant, or shale, which, mingling with the coal-dust, reduced its explosiveness. In deeper and hotter mines, it would not be advisable to water the roads, as this would have a tendency to propagate *Ankylostoma*, and, by creating a moist and hot atmosphere, prove injurious to the colliers' health. It seems to me that in the deep mines of the future there are only two known things that we can do, and these are:—(1) To use steel or iron tubs, which will not allow the dust, made in transit, to fall on the roads; and (2) to have periodical cleanings of the main wagon-roads, perhaps using a jet of compressed air to remove the dust from the crannies of the sides and roof.

If we could have something in the nature of a vacuum-cleaner, using compressed air in an injector or fan to deliver the dust into a long water-tank or wagon, wherein the water was agitated, it might help us; but dust occurrs in such quantities that it is difficult to deal with it. Mr. John Gerrard, in his evidence before the Royal Commission on Mines, refers to such an apparatus having been coupled to a screen. Some five or six years ago, something of the kind was tried at a revolving screen at the collieries with which I am connected, but it was not very [redacted]

fathers: no longer rough-and-tumble, now that it is worked by skilled engineers, with the best pumps and winding tackle in the world, but still the same in principle. This is doubtless in most cases the best and cheapest; but it has its limits, and even when successfully applied, as it has been at the Maypole colliery, Wigan, and at Manton colliery, Nottingham, the cost of some of the depths per foot must have been enormous.

One of the great difficulties at increased depths is the great pressure on the pumps, which causes the sand to cut the clacks and rams to pieces so quickly; and, when everything is pumping at full stretch, it is often a very serious and difficult operation to change a pump. The "Tomson," a modified pumping system, is in use in Germany: as soon as the pit is started, if necessary, or as soon as the volume of water and depth of lift warrant it, two large cylindrical tanks, each suspended by two strong capstan-cables, are placed on each side of the pit, and these tanks follow the sinkers, and are lowered down, foot by foot. Into these tanks, two large cylindrical buckets are dipped, using the capstan-cables as guides, and by this means a large quantity of water can be safely wound out of the shaft. The sinking pumps proper, driven by compressed air or electricity, pump into these tanks; and, as the lift is small, say, 10 to 30 feet, there is comparatively little cutting of the valve-seatings and rams, and a comparatively small motor will lift an immense body of water.

The question of tubbing *versus* pumping is a very momentous one, and after we have worked it out to the best of our ability with the data to hand, it is difficult to arrive at a definite conclusion. It might help us if we had more figures giving the decrease of work done at large colliery pumping-stations as years go by. These figures might be collected from time to time, and calculations worked out from them; they would certainly be of scientific interest, and they would lead to discussion and might prove of great value.

Should tubbing be decided upon, what is the kind to be used? The ordinary British method is to place the plain sides of the tubbing inside the pit, the ribs being towards the strata, and the joints made watertight with wooden wedges. The so-called German method, but which I believe was first used in Great Britain, has the flanges turned towards the centre of the pit, and is put in as the pit goes down, each ring being concreted to the

strata behind, after it has been secured with bolts to the ring above. The segments of this tubbing are much larger than those ordinarily made in Great Britain, being about 5 feet square: all the joints are planed, a thin strip of lead being inserted, when they are bolted to each other. I think that tubbing smooth on the inside is better for ventilation and safer in case of anything falling in the pit, as there are no projecting flanges to receive a blow, but the other is more easily inserted and easier to repair. Should any papers be communicated on this subject, I hope that the question of the thickness of the tubbing will be discussed: for, although some formulæ are recorded in handbooks on mining, the information is untrustworthy, as little attention is paid to the depth and frequency of the flanges and ribs.

At the present time, a committee, appointed by the Lancashire and Cheshire Coal Association, has been preparing plans and collecting information preparatory to the establishment of a rescue-station. Leigh has been chosen as a central spot, and I hope that an office, storerooms for oxygen life-saving apparatus, and the various other appliances suitable for a rescue-station will soon be erected, together with a long gallery, in imitation of a roadway in a pit, with all the obstacles of broken timber and fallen roof through which a rescue-party might have to force its way after an explosion. The Committee hope to train men from every district of Lancashire and Cheshire, not only in the use and upkeep of the various life-saving appliances, but also to

[redacted]

late Majesty's chief inspector of mines, we have one of our oldest and most respected members.

And now, gentlemen, although I have not given you anything new in this address, or gone into any detail on any subject, I hope that my remarks may stimulate others to carry on carefully and diligently research in the various subjects mentioned; and that, through their efforts, this Society may not only receive benefit enuring to its own members, but be the means of forwarding the solution of many of those difficult problems that affect the safe and successful working of that mineral, upon which the prosperity of our country so largely depends.

Mr. JOSEPH DICKINSON, F.G.S., in moving a vote of thanks to the President for his address, said that while he agreed with the President on most of the points mentioned in his address, he would, if discussion were not forbidden, call attention to one on which there might be a difference of opinion. The formal examination of a collier for ankylostomiasis might, he thought, be left with the manager.

Prof. W. BOYD DAWKINS seconded the vote of thanks, which was carried with acclamation.

The PRESIDENT (Mr. Charles Pilkington), after acknowledging the vote of thanks, said that he did not think that a manager would, as a rule, be able to tell whether or not a man was suffering from ankylostomiasis.

Mr. MARK STIRRUP, F.G.S., read a paper on "The New and the Old Geology; and the New Ideas of Matter."

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT WAKEFIELD, DECEMBER 12TH, 1906.

MR. J. R. R. WILSON, PRESIDENT, IN THE CHAIR.

The following gentlemen, having been duly nominated, were elected:—

MEMBERS—

Mr. WILLIAM CLARKE, Mining Engineer, Lees Hall, Meersbrook, Sheffield.

Mr. ROBERT GEORGE HIGBY, Mining and Civil Engineer, Baltic House, 27, Leadenhall Street, London, E.C.

Mr. HAROLD C. JENKINS, Electrical Engineer, Bank Chambers, Fargate, Sheffield.

Mr. WILLIAM F. MYLAN, Electrical Engineer, Bank Chambers, Fargate, Sheffield.

Mr. JOE STANCLIFF, Mining Engineer, 185, Hyde Park Road, Leeds.

Mr. HORACE TREMLETT, Manager of the Montrose Gold-mining and Exploration Company, Limited, Johannesburg, Transvaal.

[redacted]

COST OF AN ELECTRICAL UNIT AT A COLLIERY.

By PERCY C. GREAVES.

The writer, in presenting the following notes, simply wishes to place before the members the actual cost of producing electricity at a colliery under normal conditions. It is not contended that it is produced as cheaply as possible. He has found opinions differ greatly as to the actual cost, and as he has made an experiment he thinks that it may be of interest to the members.

The plant used for the experiment consists of two 50 kilowatts generators, working at a pressure of 500 volts, built by Mr. Wilson Hartnell, and coupled directly to two Willans central-valve engines running at 460 revolutions per minute under a steam-pressure of 100 pounds per square inch. The boiler is attached to this plant alone, so that accurate results can be obtained. The period of the trial was one week.

The motors and machinery driven by this generator are as follows:—One 24 kilowatts motor driving a main-and-tail-rope haulage-plant; one 1 horsepower motor driving a centrifugal pump; one 42 horsepower motor driving a ram-pump; one 10 horsepower motor driving a ram-pump; one 15 horsepower motor driving machinery in fitting-shops; and three Diamond coal-cutters driven by motors of 20 horsepower each. In addition, there are 115 lights in the pit-bottom, coupled in series.

The two dynamos are run in parallel, and, at a certain period of the day, one is stopped and the other does the work alone. A self-recording watt-meter was put down to ascertain the number of units used by the plant. In one week, from Saturday night to Saturday night, 4,400 units were consumed; during the same period the boiler used 33 tons 12 cwts. of coal. The following stores were consumed by the plant: 9 gallons of engine-oil, ½ gallon of cylinder-oil, and 2 pounds of waste. The wages of the attendants, one on each shift, were £2 12s. The quality of the coal used was very inferior, 8 tons being bastard

cannel, while 17 tons 17 cwts. of coal had been in stock for about two years, and, in the writer's opinion, the full value of this fuel was 3s. 6d. per ton. Consequently, on this basis, the costs were as follows:—Coal, 33 tons 12 cwts. at 3s. 6d. per ton, £5 17s. 7d.; oil, 9½ gallons, 18s. 6d.; wages, £2 12s.; cleaning waste, 2 pounds at 2d., 4d.; and the total cost of £9 8s. 5d. is equivalent to 0·51d. a unit. In addition to this, there is the depreciation of plant and interest on the outlay.

A portion of this plant was bought when prices were high, so that it is hardly a fair criterion; but, taking the cost of the boiler, engine-house, and two plants at £2,000, and allowing 15 per cent. for depreciation of plant and interest on capital, it would amount to £5 15s. 4d. per week, and the cost of insurance of the dynamos is 2s. 6d. per week. The total cost will then become £15 6s. 3d. or 0·83d. per unit.

The trial was continued during the following week, when 4,428 units were used, and the results were as follows:—Coal, 34 tons 4 cwts. at 3s. 6d. per ton, £5 19s. 8d.; oil, 9½ gallons, 18s. 6d.; waste, 1 pound, 2d.; wages, £2 12s.; boiler-cleaning, 4s.; interest, depreciation and insurance, £5 17s. 10d.; making a total cost of £15 12s. 2d. or 0·83d. per unit.

Having made these two tests, the writer thought that he would like to know how many units were used by a coal-cutter in normal working, for which purpose all the lights and other motors were cut off, so that the watt-meter would register the

The coal-cutting machine was working about 1,700 yards from the switch-board where the test was taken, and thus all losses by transmission were taken into account.

It may be explained that an electrical unit is 1 kilowatt-hour (1,000 watts per working hour) and this is equal to 1·34 horsepower acting for 1 hour. It was defined by Act of Parliament in 1882.

DISCUSSION OF MR. P. C. GREAVES' PAPER ON THE "COST OF AN ELECTRICAL UNIT AT A COLLIERY,"* AND MR. A. J. TONGE'S PAPER ON "A COLLIERY-PLANT: ITS ECONOMY AND WASTE."†

Mr. G. BLAKE WALKER (Barnsley) wrote that he had been asked to open the discussion on these very interesting papers but would have preferred this to have been done by someone who could have brought the results of original investigation and experiments, which, unfortunately, he had not recently been able to do. At various times different departments of mining engineering attracted special attention, and the subject which was at the present moment most engrossing was that of the production of economical power, to which question Mr. Tonge had ably addressed himself. There were plenty of reasons for this. The pressure of highly competitive times, the increased requirements for power, and the general low efficiency of colliery-machinery as compared with that employed in other industries, constituted one set of reasons. Another was the knowledge of the marvellous strides recently made in connection with the generation of electricity, the advent of the large gas-engine, and the exhaust-turbine. The low efficiency of the steam-engine as a utilizer of heat had long been the despair of engineers. Losses occurred at every stage, in the fire-box, in the boiler, in the steam-pipes, in the ports and in the cylinders. Hence only about 6 per cent. of the heat produced was converted into work. To quote the evidence of Mr. G. T. Beilby before the Royal Commission on Coal-supplies,‡ "When it becomes generally recog-

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 363.

† *Ibid.*, 1905, vol. xxix., page 153; and 1905, vol. xxx., page 249.

‡ *Second Report of the Royal Commission on Coal-supplies*, 1904 [Cd. 1991], vol. ii., page 43.

nized that the power required in mines and factories can be obtained at one-fourth to one-half of its present cost, the transformation from steam to gas will proceed very rapidly."

Gas, however, was not the only way of increasing the efficiency of fuel, and the whole question of the comparative economy to be derived from steam-engines of the highest type, steam-turbines and gas-engines, had recently been exhaustively treated by Prof. Georg Baum, Berlin, in a paper* which had appeared since Mr. Tonge's paper was written. He (Mr. Walker) did not think that he could contribute more usefully to this discussion than by giving some of Prof. Baum's conclusions. Here are a few useful figures: take the cost of steam with a plant of two Cornish boilers, each with 860 square feet of heating-surface, produce together 3·2 tons of steam in one hour, or 76·8 tons in 24 hours. If fired 12 hours a day and 300 days in the year, standing cold six days in the year, the following figures may be taken: With coals at 9s. per ton, a capital outlay of £1,400, and an efficiency of plant of 70 per cent., the cost of a ton of saturated steam would be about 1s. 7d. If the coal be put at 4s. 6d., the cost of a ton of saturated steam would be about 11d.† At Scharnhorst colliery, near Dortmund, the waste-gases from eighty Otto bye-product ovens are used under ten boilers. The quantity of steam produced is 378 tons per diem. The feed-water temperature was 134° Fahr. from a central condensation-plant.‡

Mr. Tonge gives a comparative table of the relative efficiency of electric and steam driving.§ Table I. contains the particu-

[redacted]

TABLE I.—COSTS OF STEAM-POWER AND ELECTRICAL POWER AT A SILESIAN COLLIERY.

	Description of Plant.	Power used.	Steam-power. Working Time during the Year.	Cost per Day.			Cost of Working.	Electrical-power. Working Time during the Year.	Cost per Day.			Cost of Working.	Saving.
		Horse-power.	Days.	£	s.	d.	£	Days.	£	s.	d.	£	£
1.	Haulage-winches ...	18	300	0	7	6	112	300	0	4	6	67	45
2.	Rope-haulage, 1	20	300	0	8	6	128	300	0	6	0	90	38
3.	,, ,, 2	20	300	0	8	6	127	300	0	6	0	90	37
4.	,, ,, 3	20	300	0	8	6	128	300	0	6	0	90	38
5.	Ventilating fans, 1	25	360	0	18	6	333	360	0	15	0	270	63
6.	,, ,, 2	60	360	1	10	0	540	360	1	4	6	441	99
7.	,, ,, 3	65	360	1	11	6	567	360	1	4	6	441	126
8.	Screening	65	300	0	14	6	217	300	0	11	0	165	52
9.	Centrifugal pumps, 1	2	360	0	10	0	180	360	0	2	0	36	144
10.	,, ,, 2	2	360	0	10	0	180	360	0	2	0	36	144
11.	,, ,, 3	3	360	0	10	0	180	360	0	2	0	36	144
12.	Belts ... 1	25	300	0	11	0	165	300	0	8	0	120	45
13.	,, ... 2	25	300	0	11	0	165	300	0	8	0	120	45
14.	,, ... 3	25	300	0	11	0	165	300	0	8	0	120	45
15.	Coal-hoists ... 1	25	300	0	6	6	98	300	0	4	6	68	30
16.	,, ... 2	65	310	0	15	0	232	300	0	11	0	165	67
17.	Ash-hoist	4	360	0	2	0	36	360	0	1	0	18	18
18.	Workshops ...	23	350	0	5	0	88	350	0	5	0	88	0
19.	Electric lighting ...	100	360	1	8	0	504	360	1	4	0	432	72
	Totals ...	592					£4,145					£2,893	£1,252

at the Liége Exhibition, gives some figures with regard to a colliery central-station plant to yield 1,200 electrical horsepower continuously.* The cost, detailed in Table II., may seem large, and is perhaps for a higher class of work than is usual at

TABLE II.—COST OF ELECTRICAL PLANT TO GENERATE 1,200 HORSEPOWER.

Two gas-motors, each of 600 horsepower, including pipe-mains, erected complete	£8,000
One gas-motor of 600 horsepower, in reserve, for use during cleaning, stoppages, etc.	4,000
Three dynamos, including pulleys	4,500
Switchboard	850
Two exciters	500
Foundations	600
Enginehouse	1,250
Travelling crane, 15 tons capacity	600
Contingencies, say, 20 per cent.	4,060
Total ...	£24,360

* *Glückauf*, 1906, vol. xlii., page 1035.

British collieries, but it is just as well to be on the safe side. The establishment or plant cost of this central station is about £20 per horsepower, or £27 per kilowatt. Leaving the cost of reserve-motors out of account, the actual cost of a number of completed plants is detailed in Table III.* With large plants, the establishment-charges vary to the advantage of the cost of production so that a plant with an output of 5,150 horsepower or 3,790 kilowatts, inclusive of purifying plant, should be installed for £14 per kilowatt.

TABLE III.—ACTUAL COSTS OF ELECTRICAL PLANTS OF 120, 550, 900 AND 1,800 HORSEPOWER.

Engine-output ... horsepower	120	550	900	1,800
Electric output ... kilowatts	88	404	662	1,315
Cost of electrical plant: dynamo	£375	£1,015	£2,650	£5,000*
Do. switchboard	100	75		850
Totals ...	£475	£1,090	£2,650	£5,850
Plant-costs: purifying plant ...	£1,700	£1,650	£2,000	£3,000
Do. gas-engine plant ...	2,145	4,889	7,225	14,450
Do. electrical plant ...	475	1,090	2,650	5,850
Totals ...	£4,320	£7,629	£11,875	£23,300
Plant-costs per kilowatt	£49	£19	£18	£17

* Three machines.

The cost of working a gas-power plant of 1,200 horsepower is somewhat as follows:—The value of coke-oven gas may be taken at a low figure, because hitherto an equivalent amount of heat [redacted]

various plants, estimates the cost as follows:—Gas-engines and connections, £20,300; purifying plant, £3,000; and reserve-engines, £4,650: a total of £27,950. On account of the heavy wear-and-tear of gas-engines, he reckons interest at 16 per cent. or £4,473 a year, equal to 12s. 5d. per working hour, a considerably higher figure than the 7s. used in the previous estimate.*

TABLE IV.—COST OF WORKING A GAS-POWER PLANT OF 1,200 HORSEPOWER.

	s.	d.	s.	d.
Interest and sinking fund			7	0
Cost of gas	4	2		
Attendance	3	3		
Cooling water	2	4		
Oil	0	9		
Cleaning	0	6		
			11	0
Total			18	0

Mr. Tonge uses a Parsons turbine to produce electricity, and gives the efficiency of this engine at 19 pounds of steam per indicated horsepower. Table V., detailing experiments on a Melms-Pfenniger turbine of 500 kilowatts, gives an even better result, namely, 17·14 pounds per kilowatt-hour, or 11·88 pounds per horsepower-hour.† This excellent result is in a great measure due to the use of superheated steam.

TABLE V.—EXPERIMENTS ON A MELMS-PFENNIGER TURBINE OF 500 KILOWATTS.‡

No. of Experiment.	1.	2.	3.	4.	5.
Percentages of full load	100	80	56	30	Empty with exciter
Load in kilowatts	500	400	280	150	...
Average number of revolutions per minute.	2,459	2,469	2,477	2,489	2,516
Absolute pressure of steam entering the turbine in pounds per square inch.	201	200	202	192	196
Temperature of steam in degrees Cent.	319·4	312·4	308·2	306·2	289·2
Weight of condensed steam in pounds per kilowatt-hour.	17·14	17·46	18·48	22·44	...

Turbines possess the great advantage of being suited to the use of highly superheated steam, and an experiment recently carried out in the Technical School at Dresden holds out hopes

* *Glückauf*, 1906, vol. xlii., page 1036. † *Ibid.*, page 1137.

‡ *Ibid.*, page 1137.

of further advantage from the interposition of a second superheater between the high-pressure and low-pressure portions of the turbine. The experiments were made upon a turbine of the Laval type, with a capacity of 100 kilowatts. Steam is passed into the turbine through a superheater, and the exhaust-steam passes through a tubular regenerator before going to the condenser. The surplus heat is used for heating the feed-water. A second superheater is interposed at the point at which the expanded steam has a pressure of about 15 pounds per square inch and the saving thus effected is very important, as will be seen from the figures detailed in Table VI.* It was

TABLE VI.—EXPERIMENTS WITH SUPERHEATED STEAM IN A LAVAL TURBINE.

Superheat of steam.	Degrees Cent.	300	400	500	600
(1) Single turbine, with regenerator.	Percentage of efficiency due to superheating.	12·3	17·5	22·6	27·9
(2) Double-stage turbine: initial steam-pressure 105 pounds per square inch, final pressure 15 pounds per square inch in high-pressure section, and 15 to 14 pounds per square inch in low-pressure section. With superheating between high-pressure and low-pressure sections.	Superheating: high-pressure stage. Degrees Cent.	300	300	300	300
	Superheating: low-pressure stage. Degrees Cent.	300	400	500	600
	Percentage of efficiency due to superheating.	2·0	9·2	16·1	22·7

[redacted]

Mr. F. Schulte estimates the cost of a plant, with turbines of 1,200 horsepower, at, say, £20,000 (see Table VII.) as compared with £27,000 for a gas-engine plant.*

TABLE VII.—COST OF TURBINE-PLANT OF 1,200 HORSEPOWER.

Buildings	£450
Steam-turbogen, of 1,200 horsepower	5,250
,, reserve, of 600 horsepower	3,000
Transformer, switchboard, etc.	650
Crane	150
Steam-pipes	300
Duplicates, 10 per cent.	900
Boiler-house	2,500
Boilers	3,200
Seating, chimney, etc.	800
Feed-pumps, steam-separators, etc.	375
Contingencies	2,000
Total ...	£19,575

Mr. W. Maurice recently described the exhaust-steam turbine on the Rateau system, at the Hucknall Torkard collieries.† There can be no doubt that this remarkable invention forms one of the greatest and simplest means of reducing colliery-consumption at old pits. The primary engine, developing 1,100 horsepower at 0·144d. per horsepower-hour, costs 13s. 3d. per hour; the secondary plant, developing 500 horsepower at 0·096d. per horsepower-hour, costs 4s. per hour, and also 600 horsepower, at *nil*; and the total of 2,200 horsepower will cost 0·094d. per horsepower-hour, or 17s. 3d. per hour. The value of the coal used to produce the power would, therefore, be reduced from £6,750 to £4,500 per annum. It is to practical savings of this nature that such a paper as Mr. Tonge's should direct us.

Mr. J. F. LEE (Dinnington) wrote that mining engineers were generally content with making comparisons, instead of getting at the actual cost of producing electrical motive power for colliery-work, and the information given by Mr. P. C. Greaves was interesting, as it afforded some idea of the cost of obtaining an electrical unit with a direct-current plant. There was some difficulty in getting at the output of motors with varying loads,

* *Glückauf*, 1906, vol. xlii., pages 1140 and 1141.

† "A Rateau Exhaust-steam-driven Three-phase Haulage Plant," by Mr. W. Maurice, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 118.

such as those working hauling and other kinds of colliery-plant; and for this purpose it was necessary to have check readings so as to obtain reliable figures, by having a double set of instruments, or to have them tested to ensure accuracy, as from his (Mr. Lee's) own experience, unless the output was checked one was apt to be led astray. He noticed that Mr. P. C. Greaves had made two separate tests, which came out at exactly the same cost per unit. This was satisfactory as a comparative test, but for the accuracy of the actual cost it would be interesting to know how the readings of the self-recording wattmeter were checked. Were there two in use, or was the instrument tested before and after the trials, so as to ensure a correct record of the work? The cost of 0·51d. per unit, without depreciation and interest on capital, seemed rather high, as compared with the results of some tests made by the writer on a three-phase plant. An induction-test was run for 6 hours on a generator of 225 kilowatts, actuated by a Robey cross-compound condensing engine, with a rope-driving connection to the generator. Separate boilers were used so as to arrive at the amount of fuel consumed, and the following results were obtained:—Mean indicated horsepower, 407; mean electric horsepower, 298; loss in friction of engine, ropes and generator-bearings, 27 per cent.; and overall efficiency, 73 per cent. The costs were as follow:—Fuel, 7 tons of ordinary pit-slack, made through holes, 1 inch square, at 4s. per ton, £1 8s.; stores, 9d.; labour, 11s. 9d.; and the total, £2 0s. 6d., was equal to 0·365d. per unit on the output obtained.

[redacted]

and, in the application of electricity to winding, a failure might not be rapidly localized. Simplicity was worth a great deal, and the steam winding-engine was a very simple machine which rarely went wrong: when it did go wrong, the fault was quickly found. But that was not the case with an electrical machine, and the economy would soon be gone if they had 300 to 400 men in a pit, drawing wages for nothing, while a machine was being examined. When tests were made, the conditions were usually the best for the purpose, and if anything went wrong it was a case of "that is no use, we will start again," but that was not what happened at a colliery. There were many things that interfered with the economy of an irregular-running engine, which was dependent upon normal conditions for the economy that it claimed. He (Mr. Chambers) also asked with what sort of engines the comparisons had been made. He was afraid that they were not made with the most efficient steam-engine, whilst he took it that the electrical installations were of the most modern type. They could find steam-engines that were exceedingly extravagant, but why should such engines be used for these comparisons? A high-class steam-engine, situated close to the boilers, where the steam was condensed and the heat utilized to heat the feed-water, so that it went back into the boilers at boiling point, was a good and economical machine. He did not know that they had had any mechanical expert to take up the case on behalf of the steam-engine: they had had plenty of experts to advocate electricity, some to serve their self interests, but so far as he knew, no mechanical engineer had gone deeply into the question as to how far a steam-engine could be made to give better results than those in the comparisons set before them. At a recent meeting of electrical engineers, Mr. C. P. Markham mentioned a winding-engine which he described as the most economical in the country,* and Mr. W. C. Mountain, although an electrical engineer, at an electrical engineers' meeting, had made out a very good case for the steam-engine.†

As to coal-consumption, they had the quality of the coal

* *Journal of the Institution of Electrical Engineers*, 1906, vol. xxxvi., page 520.

† "Electric Winding in Main Shafts considered Practically and Commercially," *Journal of the Institution of Electrical Engineers*, 1906, vol. xxxvi., page 499; and "Commercial Possibilities of Electric Winding for Main Shafts and Auxiliary Work," *Trans. Inst. M. E.*, 1906, vol. xxxi., page 329.

to consider. The same coal that was burned for steam-boilers might not be suitable for gas-engines. At the colliery to which he referred, the coal used for generating steam passed through meshes, 0·118 inch (3 millimetres) square: it contained 25 per cent. of ash and about 16 per cent. of water. It was of no use for gas-making, and indeed was of no use for anything but the purpose for which it was used. It was produced at coal-washers, and they had been at a great deal of trouble to find what to do with it. They had succeeded in utilizing it for raising steam, it was unsaleable, and if they had not burned it they would probably have had to put it on the refuse-heap. Such circumstances as these had a very important bearing upon the economical investment of capital in machinery and engines.

A colliery manager was supposed to know a good deal: he knew something about mining, he had to be a fairly expert diplomat, and he was supposed to be something of a financier, a civil engineer, a lawyer, a geologist, a horse-dealer, a timber-merchant, an electrical engineer, a metallurgist, a chemist, a doctor, an accountant, and one or two other things; but they could not expect him to be expert in all of them. As a solicitor on a knotty point took counsel's opinion, they wanted some assistance in the intricate problems with which they had to deal.

Another important point was that collieries were not like permanent works; and they only lasted as long as the coal. There was no value in the plant of a worked-out colliery, which [redacted]

liery was completed, except when a quick and large return on the investment was assured. Before existing steam-engines were discarded as obsolete and extravagant, it was worth while to consider what could be done to improve them and at what cost, by altering the valve-gear and putting on condensers, such as were usually provided for the prime motors of an electric installation; and the probability was that in many cases it would be found to be much less expensive and attain a near proximity to the highest efficiency.

Mr. H. St. J. Durnford (Leeds) thought that Mr. Greaves had put a low price upon his coal, as it should be worth more than 3s 6d. per ton. He asked how the price at which current could be bought from, say, the Yorkshire Power Company, Limited, compared with 0·83d. per unit, quoted in the paper, and also how Mr. Greaves' figures compared with Mr. Walker's.

Mr. M. H. Habershon (Thorncliffe) said that, in Westphalia, a company having several hundred miles of cable collected the electric power generated at the collieries in the district, and paid ⅜d. per unit for it. At a meeting of the Institution of Electrical Engineers held at Leeds, in 1905,* it was stated that the cost of generating electric current with an engine of 500 indicated horsepower driving a dynamo of 270 kilowatts, working 3,000 hours per annum with an average load of 80 per cent. and coal at 6s. 8d. per ton, amounted to 0·418d. per brake-horsepower-hour; and with a suction gas-plant of similar capacity, on the same average load, but with anthracite-cobbles at 25s. per ton, the total working cost was estimated at 0·35d. per brake-horsepower-hour.

Referring to Mr. Tonge's remark as to the possibility of effecting economies in fully developed mines more easily than in new ones, he thought that it was open to doubt, and things might rather be the other way about. It had been given in evidence before the Royal Commission on Coal-supplies,† that at one colliery an increase of 1,000 feet in the depth of the workings had increased the coal-consumption from 5 to 10½ per cent.

* "Power-gas," by Dr. F. H. Bowman, *Electrical Review*, 1905, vol. lvi., page 666; *Electrician*, 1905, vol. liv., page 1005; and *Colliery Guardian*, 1905, vol. lxxxix., page 582.

† *First Report of the Royal Commission on Coal-supplies*, 1903 [Cd. 1725], vol. ii., page 21.

If Mr. Tonge's conclusion was correct, he (Mr. Habershon) thought that it was a strong argument in favour of electric driving being adopted at new collieries. The steam-consumption of 83 pounds per horsepower-hour in the coal raised, stated to be probably as low as could be obtained with an ordinary non-condensing winding-engine, showed that there was a margin for economy with compound engines and condensing plants, and if some member would give the Institute the results of similar tests of such engines the information would be extremely valuable. With regard to the efficiencies of 0·82 and 0·85 for the electric and steam drives given by Mr. Tonge in Table V.,* he thought that it should be remembered that in the case of the electric drive, 49 horsepower was being used for coal-cutting at a distance of about 3,300 feet, which could not be done with steam, so that the slightly higher efficiency of the steam-drive was more apparent than real.

Mr. ALFRED LUCAS (Sheffield) said that an explanation of the somewhat low efficiency of the plant described by Mr. Greaves was that on the full week's running, the load-factor was 26 kilowatts per hour whereas the total plant capacity was 100 kilowatts. The figures given by Mr. Lee referred to a generator of 220 kilowatts running at full capacity for six hours, which was a very different condition.

Mr. ISAAC HODGES (Normanton) said that he was glad that at [redacted]

engine than credited to the advantage of electricity. He thought that it would be wise on the part of colliery managers to look carefully into the merits of their existing plant, and see how far it could be modernized and made economical before deciding to root it up in favour of large electrical installations, as he was of opinion that steam-plants had been removed for defects that might have been easily remedied, and thus made as efficient as electrical plants at a tithe of the cost of the exchange. At the Whitwood collieries, by bringing the steam-engines nearer to the boilers and fitting them with expansion-gears, by removing steam-mains from pit-shafts, and by coupling underground machinery to existing compressed-air plants, an economy of upwards of £3,000 per annum in fuel alone had been made without resorting to any system of electricity, and this had the great advantage of having involved no particular capital expenditure. It should not be forgotten that the greatest faults of steam-plants were the serious losses caused by condensation in long steam-mains. Three years ago he had occasion to discontinue the use of a main-and-tail-rope hauling-engine, with a single cylinder 18 inches in diameter and 3 feet stroke, running at 70 revolutions per minute, situated underground at a depth of 450 feet: and the steam-main was left in the shaft for the purpose of supplying steam to a pump in the same seam. Greatly to his surprise, scarcely any reduction in fuel resulted from the stoppage of the steam-engine; but, when the pump was driven by compressed air, and the steam-main had been removed from the shaft, two Lancashire boilers, 28 feet long and 8 feet in diameter were dispensed with, although the steam-main had been encased with strips of woven-silicate-cotton yarn and protected by a further covering of canvas and pitch.

From experiments extending over a period of several years at the Whitwood collieries, he (Mr. Hodges) had ascertained that the cost of steam raised by means of Haigh-moor smudge (containing $22\frac{1}{2}$ per cent. of ash, screened through holes $\frac{3}{8}$ inch in diameter, 8 pounds of fuel being burnt per indicated horsepower-hour and priced at 3s. 6d. per ton), when used in first-class colliery engines, was 0·18d. per indicated horsepower-hour for fuel only, including the fuel used in banking fires during nights and week-ends amounting to 18·33 per cent. of the total consumption. The cost of labour employed in firing and removing ashes, including

the cost of water, was 0·05d. per indicated horsepower-hour; the interest on capital expended on boilers, with fittings and seatings, pumps and feed-pipes, house and chimney at 4 per cent. and depreciation on capital at 5 per cent., was 0·04d.; making a total working cost of 0·27d. per indicated horsepower-hour; and, allowing 15 per cent. for loss in conversion, it was equal to 0·31d. per brake-horsepower-hour.

It might be assumed that Mr. Greaves, with his modern high-speed steam-power plant and with coal also at 3s. 6d. per ton, would produce his power at an equal or less cost than 0·31d. per brake-horsepower-hour; and he (Mr. Hodges) could not understand why Mr. Greaves' coal-cutters should have cost $\frac{3}{4}$d. per brake-horsepower-hour, a loss of nearly $\frac{1}{2}$d. per unit in transmission. He (Mr. Hodges) would like Mr. Greaves to state the cause of such a high loss as 60 per cent., and, if possible, give the details, as he was distinctly of opinion that equal results could have been achieved by compressed air. The very small load-factor, it had been pointed out, was the chief difficulty that the Yorkshire Electric Power Company had to overcome in offering sufficiently low prices to collieries. He himself had found great difficulty in guaranteeing a high load-factor, and was not surprised that Mr. Greaves should have been unable to show a higher load-factor than 27 per cent. He congratulated Mr. Greaves on his plant being erected in two units, as he had found from experience that a plant of several units, running in parallel, was the only means of allowing the apportionment of the power

[redacted]

For the purposes of this discussion, the period from 1·30 p.m. on November 29th to 1·30 p.m. on December 6th, 1906, was taken, and 20,052 Board-of-Trade units were produced. Two Lancashire boilers, 30 feet long and 8 feet in diameter, working at a pressure of 100 pounds per square inch, used 89¼ tons of coal valued at £15 2s. 3d.; enginemen and firemen's wages were £5 4s.; stores cost 17s. 9d.; cleaning boilers and flues, 3s.; the total cost was £21 7s., equal to about 0·26d. per unit; and, including capital charges, etc., the cost would be 0·49d. per unit.

Mr. W. B. SHAW thought that Mr. Greaves' figures were valuable, because they were taken over a considerable period and under working conditions. Few statements of the actual working costs of colliery generating plants, particularly small plants, had been published. Special tests of steam-consumptions at different loads were of little value as a guide to the coal-consumption of a small plant taken over the whole year; for, as had been pointed out, so much depended on the load-factor.

The following results of a test of a small generating plant at Hulton colliery would, he thought, illustrate this point. Two non-condensing engines, each driving by a belt an 88 kilowatts direct-current generator, showed a consumption on full load of 64·5 pounds of steam per kilowatt-hour, equivalent to, say, 10½ pounds of coal. The steam used with no load on the generators amounted to slightly more than 40 per cent. of that used on full load. Taken over a whole year, the coal-consumption exceeded 20 pounds per kilowatt-hour.

TABLE VIII.—COSTS OF WORKING TURBO-GENERATING PLANT AT HULTON COLLIERY.

Year.	1904.		1905.		1906 (10 months).	
	Totals.	Per Kilowatt-hour.	Totals.	Per Kilowatt-hour.	Totals.	Per Kilowatt-hour.
Weight of coal	3,059 tons	5·3 pounds	3,298 tons	5·4 pounds	4,220 tons	4·4 pounds
Cost of coal at 5s. 6d. per ton	£841	0·156d.	£932	0·163d.	£1,160	0·129d.
Wages	£466	0·087d.	£505	0·089d.	£581	0·064d.
Stores	£53	0·010d.	£80	0·014d.	£90	0·010d.
Interest at 5 per cent. and depreciation at 10 per cent.	£1,691	0·315d.	£1,782	0·313d.	£1,996	0·222d.
Total cost	£3,051	0·568d.	£3,299	0·579d.	£3,827	0·425d.
Kilowatt-hours generated ..	1,289,000		1,366,000		2,164,000	
Load-factor*	0·54		0·49		0·45	

* The load-factor is the proportion of the average load to the maximum load during the year.

The actual working costs for the generating plant mentioned in Mr. Tonge's paper had been accurately kept for the last three years, and the results (Table VIII.) showed that much greater economy could be obtained from a large modern plant as compared with the smaller and older type mentioned above. The total capacity of this plant was, at present, 1,000 kilowatts (an additional generating set having been added in 1905), and steam was supplied by four Lancashire boilers, 30 feet long and 8 feet in diameter. Various classes of coal of inferior quality were used, and the price of 5s. 6d. per ton was perhaps somewhat high. He did not think that power-companies could compete with these results; and, where the amount of power required was sufficiently large, there was no doubt that it was cheaper for a colliery to have its own generating plant. Where the installation of a small plant was contemplated, the offer of a power-company, if at all reasonable, should be seriously considered, and would probably show an advantage over a private supply. If the power required was likely to increase steadily in amount, a temporary supply from the power-company might be arranged for a number of years, until the units used per annum reached a sufficiently high figure to justify the outlay on a private generating plant. The capital-outlay, up to the present time, on the generating plant at Hulton colliery, to which the table of costs given above referred, amounted to £17,817 or £17·8 per kilowatt installed. One third of the plant might be regarded as spare. The importance of the capital-outlay in its

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electrical engines of modern type were generally contrasted with steam-engines of the old type, and that it was necessary to have some practical information of the actual saving when good electrical engines and good steam-engines were contrasted; but his paper was intended to be a thoroughly practical one, and the costs and figures therein given, so far as they applied to electricity, had been realized over a definite period of time. The difficulty in such cases was not to obtain the electrical results, but the results relating to steam-engines at collieries. For purposes of comparison it was necessary to get a fair average of the steam-consumption in colliery-engines, and he had taken as fair an average as he could, having grouped together figures given by other engineers, and covering some 60 engines in all. Among these were high-class engines, such as compound condensing engines, etc., and he believed it would be found that his assumption of 56 pounds per indicated horsepower-hour would be rather under than over the average of colliery-engines. Mr. Isaac Hodges had corroborated the statement made in his paper, and also Mr. M. H. Habershon's remarks, that it was possible to effect savings upon present steam-plant by modernizing the engines and employing proper condensing arrangements, provided the engines were placed comparatively close to the boilers. Mr. Hodges had also shown how difficult it was to economize; and he agreed with him, if the engine was only a fair distance from the boilers, no matter what type of engine was employed, that the power lost by condensation of the steam in the pipes quite overwhelmed the economy obtained in the engine.

Managers should not lose sight of the fact, that in adopting labour-saving appliances some useful secondary power was generally necessary, and that only in a few directions could labour-saving appliances be applied without the use of either compressed air or electricity. The first question, therefore, was not only as to what saving could be effected by using electricity as against steam, but whether it was possible to develop thoroughly a colliery without the use of a secondary power-plant. Having taken a general view of their requirements, managers would probably find that some other power than steam was requisite; and once they had come to this conclusion they had a further question to decide as to which of the two powers they

would employ. Should it be decided to adopt electricity, it then became a matter of urgent importance to take into consideration the question of doing as much of the other work as possible through the same medium. The full economy of electricity, as against steam, could only be obtained upon such broad lines as these. If it were assumed that electricity was an absolute necessity at a large colliery, say for coal-cutting or other labour-saving appliances, and the capital-expenditure was estimated for so much of the power as was used under necessitous conditions, it would almost certainly be found that the ratio of capital-expenditure to the upkeep of the plant would be considerably reduced by embracing as much other work as possible; winding-engines, however, being quite excepted in this connection.

Mention had been made of the load-factor, and of the reduction in cost per unit to be obtained if a higher load-factor could be guaranteed. It was an interesting question as to how far economies could really be secured by putting on all regular-running engines as well as irregular-running ones, such as coal-cutting machines, and by a judicious arrangement of working the machines throughout the day. The reduction in price charged by large power-companies upon steady and high loads would, in all probability, outweigh the capital-expenditure on such parts of a colliery-plant as were not of necessity required to be driven electrically. He (Mr. Tonge) had, however, not wished to digress into this matter in his paper, but since it was read two years ago, other figures had been obtained, and it might be of interest

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it showed a considerable advantage in favour of the electrically-driven fan over the furnace. Further economies had been obtained at the same colliery by employing high-pressure motors driven from the central colliery generating-station. These high-pressure three-phase motors had taken the place of two steam-engines, which were used for driving a direct-current plant, it being found preferable to retain the direct-current installation and so save the cost of replacing all the motors by three-phase motors. The high-pressure motors absorbed 640,000 electric horsepower-hours in the year. The average electric horsepower was 74, the steam consumed per electric horsepower-hour was 22 pounds; and the coal consumed, at an evaporation of 6·3 pounds, amounted to 1,009 tons per year, and at 5s. 6d. per ton it cost £286. Under the old conditions, the same average electric horsepower consumed 4,610 tons of coal in the year, or over four times the amount used with high-pressure motors. The great difference in the ratio between the electrically-driven plant and the steam-driven plant was largely accounted for by the low loads at certain parts of the day, when the steam-engines were working very uneconomically. When the engines were working at full load, tests were made and it was found that the ratio of electric to steam-driving in coal consumed was only as 1:2. The saving effected by this alteration had therefore amounted in the first year to £981.

Mr. P. C. Greaves thought that 3s. 6d. per ton was a sufficient charge for the coal. With regard to the question of buying current, he did not think that they would be able to get it at less than 1d. per unit from power-companies whose capital-outlay he regarded as a hindrance to their competition with collieries. He agreed that the matter of load-factor was most important. He confirmed Mr. Hodges' view on that question, because at another colliery, with a plant of similar dimensions, namely, 100 kilowatts, and a larger number of motors than at the plant that he had described, the load-factor was less. There was a loss in the transmission of electricity, and the same voltage was not obtained at the far end. Under perfect conditions, with big enough cables, there might be almost an absence of loss, but he had never yet come across the pit where such conditions prevailed. The coal-cutters took more power than he anticipated,

and he thought that it would be found in practice that they took much more than the so-called 10 or 20 horsepower, as represented. Mr. Lee's figures were hardly a fair comparison, because he only took a few hours' trial with a large load-factor, and if he took a whole week the result per unit would be very different.

The discussion was closed.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING OF ASSOCIATES AND STUDENTS,
HELD AT BOWBURN WINNING, SEPTEMBER 10TH, 1906.

BOWBURN WINNING.

BY A. L. STEAVENSON.

At Bowburn winning, a shaft was seen in the process of being sunk by piling through the thick Glacial Drift of clay and sand, which covers the surface in the neighbourhood of Durham city.

As this difficult material was known to exist, a bore-hole had been put down a few feet from the position of the proposed pit, finding no rock until a depth of 156 feet 9 inches had been reached (Appendix). It was then determined that the shaft would necessitate piling, and the pit was started 25 feet in diameter, in order to make sure of finishing with a shaft 13 feet in diameter. The pit was sunk by ordinary methods to a depth of 89 feet 3 inches, through stony clay; and, on penetrating for a depth of 18 feet into the loamy clay (No. 6 bed, Appendix), it was determined that piling must begin at once.

The cribs, *a*, were 6 inches square, with backing-deals, *b*, 1¼ inches thick and 7 inches wide, and tied with stringing-deals, *c*, 1¼ inches thick and 7 inches wide. The cribs were spaced 21 inches apart, with punch-props, *d*, 4 inches in diameter. The lowest crib of this timbering was inserted at a depth of 101 feet, and the lower portion was lined with grooved and tongued deals, *e*, 1¼ inches thick and 7 inches wide (Figs. 1 and 2, Plate XVI.).

A crib, *f*, 6 inches square, was then suspended by chains, leaving a space of 2½ inches for the passage of the piles; and below this a similar crib, *g*, was laid but not hung, the segments being fastened together above and below, by iron plates, 3 feet long, 3 inches wide and ½ inch thick, bolted with six through-

bolts, and going down with the piling. The pitchpine piles, *h*, 7 inches wide and 2½ inches thick, were scarfed for a length of 6 inches, and blacklead was applied to make them travel easily. The piles were driven downward by blows from a ram of pitchpine, worked by three men: one standing near the lower end, and two at the top end. Longer rams were used as the piles descended into position. As the piles went downward, the sand below was removed, so as to keep the sinking-curb going down; and, when lowered far enough, other cribs, *a*, 6 inches square, were placed, spaced 15 inches from centre to centre. The first section was 15 feet long.

When these piles were driven down, the cribs were lined with deals, *e*, 1¼ inches thick and 7 inches wide, as before. A second crib was hung, leaving a space for another ring of piles: the outside diameter being 21 feet 6½ inches. A second length of piling was then driven down a distance of 15 feet, and a third length of piles in the same way, the outside diameter of the piling being 20 feet 4 inches. These piles were 18 feet long and shod with sheet-iron, ⅛ inch thick. The heads of all the piles were hooped with iron, 2½ inches wide and ½ inch thick.

The last crib having entered the sandstone, the usual method of sinking was resumed. After another length of 6 feet had been accomplished, a good crib-bed was made, and all this bad ground was walled off with two rings of firebrick-lumps, *i* and *k*, 12 inches long, 9 inches wide and 3 inches thick, and cement-grouting, *j*, 3 inches thick, between them. The space behind [redacted]

with by two pumps slung in chains from the surface. It is expected that the Low Main seam will soon be reached, and at the first good rock, the water will be tubbed off.

The shaft was started 25 feet in diameter, so as to make sure of getting a finished size of 13 feet in diameter; but having been successful in getting down with less loss of dimensions than was expected, a size of 15 feet in diameter has been adopted.

Few similar sinkings necessitating piling have been required in this district; but the late Mr. G. C. Greenwell described the piling of a pit at Framwellgate Moor 60 years ago.* In that case, the pit was started with a diameter of 30 feet, and ended with a diameter of only 14⅓ feet. Timber of sufficient strength not having been used, at one point the pit was filled with ashes; and the sinking was recommenced with stronger timber, eventually getting into blue metal-stone at a depth of 120 feet.

The late Mr. Edward Potter described the piling of a pit through the sand at the bottom of the Magnesian Limestone.† In this case, the pits having been tubbed to a depth of 456 feet, were belled-out from 14 feet, the finished size, to a diameter of 21½ feet. As much as 9,306 gallons of water per minute was pumped at one time.

About ¼ mile to the east of this Bowburn pit is an old shaft sunk by the late Mr. Quelch. He was most unfortunate, for, having passed through the Low Main and Hutton seams, both too thin to work in those times of 50 years ago, he bored to a point at which he should have found the Bustybank seam. However, there happened to be a nip-out, and he abandoned the sinking with, no doubt, considerable loss. Had his pit been sunk a few feet further west, he would have got nearly 5 feet of coal, as proved by the present owners. The moral to be drawn is: "In cases of importance do not trust a single bore-hole." This old pit is lined with timber tubbing, and it is still quite good.

The late Mr. G. C. Greenwell described the mode of inserting timber tubbing,‡ and stated that it was not uncommon to see a

* *A Practical Treatise on Mine Engineering*, by Mr. G. C. Greenwell, 1855, page 127; and second edition, 1869, page 160.

† "Murton Winning in the County of Durham," by Mr. Edward Potter, *Trans. N. E. Inst.*, 1856, vol. v., page 43.

‡ *A Treatise on the Winning and Working of Collieries*, by Mr. Matthias Dunn, 1848, page 92; and second edition, 1852, page 49. *A Practical Treatise on Mine Engineering*, by Mr. G. C. Greenwell, 1855, page 135; and second edition, 1869, page 170.

tub of this description sustain a pressure of 300 feet of water. The previous system of plank-tubbing, used when sinking Hebburn colliery in 1790, is also described by Mr. G. C. Greenwell.*

APPENDIX.—SECTION OF STRATA PASSED IN A BORE-HOLE AT BOWBURN WINNING, JANUARY, 1906.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
1	Soil	1	0	1	0
2	Yellow clay	1	2	2	2
3	Stony clay	14	2	16	4
4	Sand-parting, with water	0	7	16	11
5	Stony clay	72	4	89	3
6	Loamy clay	19	7	108	10
7	Quicksand	4	6	113	4
8	Leafy clay	16	8	130	0
9	Stony clay	2	2	132	2
10	Loam...	3	4	135	6
11	Clay, loam, sand and gravel, with water	6	9	142	3
12	Stony clay	14	6	156	9
13	Freestone	5	3	162	0

NOTE.—The borers stated that, so far as they could judge, there would not be any great feeders of water to be dealt with, but it will be observed that, from the depth of 90 feet, difficult ground was encountered.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
OCTOBER 13TH, 1906.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

DEATH OF MR. JOHN DAGLISH.

MR. THOMAS DOUGLAS said that, as one of the few surviving original members of the Institute and for many years a personal friend of the late Mr. John Daglish, he felt that he might say a few words with reference to his recent death. The Institute, like everything else, had a beginning; and, recalling the earliest day in the life of the Institute, he well remembered meeting the late Mr. John Daglish and the late Mr. Nicholas Wood, along with a few other gentlemen, on July 3rd, 1852, the outcome of which meeting was the establishment of the North of England Institute of Mining Engineers. It was to the mining engineers of that period, and others since eminent in the profession, that the members were largely indebted for the position which the Institute enjoyed and had always maintained, for the purpose of disseminating every possible influence to guide others in reference to matters connected with mine-engineering; and if there was one man more than another who had advanced the interests of the Institute it was their late friend. Of course, in that connection, he excepted the late Mr. Nicholas Wood, who took such an enormous interest in the Institute, and to whom they had been so greatly indebted for its maintenance in the large amount of time that he had devoted and the great number of papers that he had gathered together for the information of the members. He (Mr. Douglas) proposed that the members should express to Mr. Daglish's widow their deepest sympathy in her bereavement, and their high appreciation of her late husband's merits and of the help which he had given to the Institute during the many years that he had been connected with it.

Mr. A. L. Steavenson, in seconding the proposal, remarked that, although he himself did not become a member of the Institute until 1855, he was well aware of the great interest that Mr. Daglish had always taken in the affairs of the Institute. He had written many papers, and conducted many experiments and tests, notably with regard to mine-ventilation. As involving the loss of a personal friend, Mr. Daglish's death was a very great shock to himself, and he was sure that it was a very great loss to the Institute.

The President (Mr. J. H. Merivale) said that Mr. Daglish was one of the original members, and by his death only three now survived, namely, Mr. Charles William Anderson, Mr. Cuthbert Berkley and Mr. Thomas Douglas, all of whom the members hoped might be spared for many years yet to come. Mr. Daglish had taken an interest in that Institute from its inception in 1852, up to the day of his death, and although he was not in a position as yet to state anything officially, yet there was reason to believe that Mr. Daglish's name would continue to be connected with the Institute in a tangible way for all time to come.

The resolution was sympathetically adopted.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on August 18th, September 29th and that day, together with the proceedings of the Council of The Institution of Mining Engineers.

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ASSOCIATES—

Mr. FRANCIS McDONALD, Miner, 164, Leadgate, S.O., County Durham.

Mr. ISAAC SCOBIE, Under-manager, Woonona, near Sydney, New South Wales, Australia.

STUDENT—

Mr. WILLIAM GRAHAM, JUN., Apprentice Mining Engineer, Solway House, Moresby, Whitehaven.

DISCUSSION OF MR. W. ARCHER'S PAPER ON "IMPROVED DAMPERS FOR COKE-OVEN FLUES."*

Mr. A. M. HEDLEY asked whether Mr. Archer could give any idea of the comparative costs of the dampers described in the paper, and the cost of renewals and repairs over a certain period, as compared with a damper of more simple construction. The first type of damper consisted of a cast-iron frame with inner cross-stays of solid bar-iron, covered and protected by overlapping fire-clay lumps; and in the second type, a framework of tubes was enclosed by a series of fire-clay lumps, air being admitted into the tubes for the purpose, as he took it, of keeping them cool and preserving them from being injured by the intense heat. The first type of damper seemed to be much simpler, and would probably cost less.

Mr. W. ARCHER said that the first cost of either damper was as cheap as that of any steel-plate damper. The plate-and-quarl damper was, if anything, more costly than the tube-and-quarl damper. A plate-and-quarl damper had been in use for three years, so that, in a case of that kind, the first cost was not a serious matter. The cost could not be stated, as the life of the plate-and-quarl damper was still running.

DISCUSSION OF MR. SAM MAVOR'S PAPER ON "PRACTICAL PROBLEMS OF MACHINE-MINING."†

Mr. H. M. HOBART (London) wrote that, until the last few years, continuous-current motors were almost exclusively used for driving coal-cutters, and many manufacturers took up the standpoint that the polyphase motor could not be applied to such work. One leading reason related to the greater diameter,

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 163.

† *Ibid.*, 1906, vol. xxxi., page 378.

then considered to be a necessary attribute of a polyphase motor, as compared with the equivalent continuous-current motor. The difficulty, however, had proved to be far less formidable than these manufacturers believed, and amongst the machines which Mr. Mavor had described, a number were equipped with polyphase induction motors. It was important to emphasize the great advantage of low periodicity for such work. This might be explained as follows: A rotor-speed of not more than 750 revolutions per minute was generally preferred for such a motor; hence, when it must be operated from a 50-cycle circuit, it must have eight poles, whereas when operated from a 25-cycle circuit it has but four poles. Obviously, four-pole windings could be brought upon a much smaller periphery than eight-pole windings. Thus, for low-periodicity circuits, a much better design could be provided for a given limiting diameter.

There were a number of ways of approaching the problem of providing sufficient starting torque for a polyphase motor. When the motor was of the squirrel-cage type, there was the advantage of absolutely no moving contacts. But, on the other hand, any considerable amount of starting torque was, in a simple squirrel-cage motor, associated with a considerable rotor loss when running at constant speed; and, as a motor for coal-cutter purposes must be of the totally enclosed type, this comparatively great loss in the rotor circuits constituted a considerable disadvantage. Nevertheless, excellent results had been obtained with squirrel-cage coal-cutter motors, due largely to the [redacted]

motor was proportioned with a very low resistance, and it would, consequently, have a negligible starting torque. During constant-speed running, however, its rotor losses were exceedingly small, and the temperature-rise was consequently smaller for the given overall dimensions. Such a motor could be a little smaller than the standard squirrel-cage motor customarily used for a coal-cutter machine, but there was the extra expense and extra space required for the starting motor, which was not very much smaller than the running motor. Nevertheless, the design was capable of being worked out very compactly, and with less overall height than was necessarily associated with a motor in which the starting and running properties were embodied in a single rotor.

A great variety of arrangements had been devised by various engineers for obtaining a good starting torque in polyphase motors, and, at the same time, avoiding the consequent large rotor loss during regular running. While many of them were too complicated to be adopted in such a case as a coal-cutter machine, where great strength and simplicity was an essential, several of the less complicated devices were well worthy of consideration in connection with the problem. The arrangement which he (Mr. Hobart) had previously described was, however, the simplest, and much might be said in its favour as a sound engineering proposition.

Continuous-current motors were largely free from these disadvantages with regard to starting; on the other hand, the commutator was by no means a desirable component of a coal-cutter motor, and the general favour with which polyphase motors had been received by mining engineers indicated that there was a large future for them in coal-cutting machinery.

Mr. T. E. Forster said that the description of the working of coal-cutting machines, and the opinions put forward, agreed very much with those recorded in the *Report of the Committee upon Mechanical Coal-cutting* of this Institute, but Mr. Mavor had had the advantage of bringing his information a great deal further up to date; and, if members had not already considered the paper, it was well worth looking into.

Dr. J. R. M. Robertson (Sydney, New South Wales) wrote that there appeared to be little necessity for Mr. Mavor to

deplore his want of mining experience in view of the thoughtful, well expressed, and sound manner in which he reasoned out the various mining problems that together have so close a bearing on the success of coal-cutting machinery. No exception could, he thought, be taken to the views enunciated in the laying-out of underground works suited to the conditions, and the reasons for so doing. So far from being a novice, Mr. Mavor possessed exceptional knowledge of exact mining, which few having long experience could approach. If mine-officials could in all cases be got to conduct operations on the sensible and correct lines that Mr. Mavor (an electrical engineer) so clearly laid down, a great step towards the more general use of coal-cutting machinery would be certain. The indifference or veiled hostility of some officials, towards adapting systems to new conditions, was in many cases the cause of the non-introduction of coal-cutting machinery.

In the general arrangement and distance between roads, the direction of the cutter-face relative to the cleavages of the coal and of the roof, Mr. Mavor in the main follows the admirable practice so clearly laid down by Mr. W. E. Garforth;* and little, he thought, could be said to improve upon these views. They appeared to embrace the whole of the questions that determined the success of coal-cutters, and there could be little doubt, with the advance of knowledge and the supervision of operations by educated go-ahead young engineers with exact ideas, that the prejudice that had in the past militated against

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however worked, any coal-seam under 5 feet in thickness should be paid for by an addition (in the Southern district) of ½d. per ton per inch to the standard rate. This rendered the working of the seams by hand impossible.

A large area of coal at Mount Kembla colliery being considerably under the standard height, and considered by the Arbitration Court unfit for miners to recover by ordinary methods, a resolution was passed to endeavour to recover the coal by means of machines. The coal-seam, in the portion selected as a trial, varied in thickness between 3 feet and 4 feet 4 inches. The coal is a steam coal and tender, it breaks in more or less columnar masses, and it has no very distinct cleavages. The floor is hard dark sandstone or fakes, the roof is dark and strong sandy bands, fakes or sandstone. It has very little dip and rise, gives off no water and an inappreciable amount of gas. The floor, however, is in parts crumpled into irregular rolls that begin at nothing, increase in size and again taper away. These are not frequent, nor in this district are they of large size: seldom more than 1 foot in height. There are no faults in the ½ mile of face selected. These physical features were the factors that were considered in determining the selection of the machines. In the harder and higher coal of the Newcastle and Maitland districts, Ingersoll punching machines, Sullivan chain-breast coal-cutters and Jeffrey chain-breast cutters had been at work. None of these were considered adapted to the conditions, while disc machines, it was argued, would have a difficulty in getting over rolls in the floor, and it was thought that the coal-seam, when undercut, would fall and possibly jam the disc. After mature consideration, a medium-sized Pickquick machine was ordered, together with an experimental direct-current plant of 50 kilowatts at 500 volts to provide power for haulage, pumping and cutting machines. The armoured cables were laid one on each side of the main road, in a trench with the usual junction-boxes and face-cables. At first, the face was formed on the planes or facings of the seam. When the machine was ordered, the services of a competent mechanic were engaged from the makers. No difficulty was experienced at all with the machine, and, in the course of a few days, the men had mastered the working of it. To his (Dr. Robertson's) surprise, all the forebodings of difficulties disappeared as day and week passed without any

hitch occurring. To emphasize the statements of Mr. Mavor, the machine was started on a face parallel with the planes or facings of the coal. It was found that an undercut 4½ feet deep and the shaking of the machine brought the seam down in flakes. To avoid flitting, the machine cut in both directions; but it was found that when the bar cut in front these falls of coal often enveloped the machine, causing many delays. In the belief that this could be remedied by cutting more on end, by a series of short cuts, the face was wheeled round so as to cut half on end. This was an improvement, and by a continuance of the short cuts the cutting face was brought at right angles to the facings. By the use of a suitable carriage, instead of cutting in both directions, the machine now only cuts one way with the bar behind, and it is flitted for a contract price of 15s. per flit.

The miners being unaccustomed to the seam, and having successfully convinced the Arbitration Court that seams, 3 feet thick, were unfit for men to work in, to be consistent carried out this belief by a marked indisposition to work in this section. To facilitate filling, the roads were brushed and built up to 9 feet wide and spaced to 30 feet centres, but much difficulty has been experienced in obtaining fillers. This deficiency has caused many delays, and restricted the work of the machine. To remedy this, the use of face-conveyors was considered; but, considering the high rates paid for labour and the lower price received for Australian coal compared with that current in Great Britain, it did not seem possible even to adopt a simple form of conveyor of

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of being able to reduce this by the new method suggested. Ordinary longwall worked by hand would give possibly a larger percentage of small coal. Gradually, the opposition and the general hostility of some of the workmen, not only to machines but to those who work them, are being worn down and will doubtless, in a short time, disappear.

Meanwhile, the face has been extended to a straight length of 1,350 feet, and a second machine has been obtained. The plan differs somewhat from that advocated by Mr. Mavor in that this face is worked from end to end with two machines, which, following each other, work about 750 feet distant, thus giving more time for filling. The roof gives little trouble. The small rolls in the floor when first struck wear down the pick-points, but no difficulty has been experienced in directing the bar and the machine itself over these irregularities. One machine has been working constantly for 15 months and the second for 3 months. Neither of these machines has caused any trouble whatever: there have been no breakdowns, and the repairs have practically been *nil*. Owing to inexperience, the machines at first received much rough usage. Contrary to the experience of others in New South Wales, who adopted American-made machines that have, as a rule, given great trouble and caused heavy expenditure for repairs, the machines at Mount Kembla colliery (being regularly examined and cleaned) have caused no stoppages, have had no breakdowns, and have incurred very little expense. Working at a distance of $\frac{3}{4}$ mile from the generator, they absorb an average of 11 to 12 horsepower, and cut from 17 to 21 inches per minute—one with a $4\frac{1}{2}$ feet undercut and the other with a $5\frac{1}{2}$ feet undercut. As a rule, the seam sags down from the roof when cut; but, occasionally, it requires a small shot to bring it down. The brushing is strong and is heavy to shoot, and possibly in course of time this expense may be somewhat reduced by increasing the distance between the gate-roads; but sufficient experience has been gained already to state that the heavy penalty imposed by the Arbitration Court can be saved by those who essay to work seams thinner than the arbitrary standard. The thin seams will be wrought by coal-cutters at possibly less cost than that paid for the thick seams, and then will realize all anticipations.

Naturally, having many unforeseen difficulties to overcome, the first machine has not produced the amount of coal that it will

from this time onwards, provided that the present conditions prevail: but, for the first year, with many short cuts and stoppages due to the coal being unfilled, etc., 23,000 tons were undercut, and a large increase on this is anticipated in the future.

The absence of any breakdowns is a tribute to the care and excellence of the workmanship and design of the Pickquick machine, which should be known to those who delay introducing machines, because of the fear of trouble from breakages that have certainly been in this case conspicuous only by their absence. In some of the Newcastle collieries, where the character of the coal-seam and the conditions are entirely different, the owners would have a wider range of machines to choose from to do their undercutting: but, so far as he had proceeded, he thought that for the conditions in the South, he could have selected no machine that would have so well fulfilled the requirements, or one that would have given so little trouble.

In respect to the renewal of picks, these are changed as a rule once in a shift, and this is not a lengthy or a difficult operation; but he had always held, and had expressed this to the makers, that by adopting some of the many special steels now on the market, picks could be produced that would give much better results. Some weeks ago, a friend, who had Sullivan machines at work in a very hard coal-seam, complained of the frequent necessity of changing the pick-points. He accepted the offer of a set of pick-points, free for a trial, made of Bowler steel, with the result that, whereas he was formerly obliged to change these

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THE VALUATION OF MINERAL PROPERTIES.

BY T. A. O'DONAHUE.

I.—DISCOUNTING DEFERRED VALUES.

Introduction.—The writer's primary object, in submitting this paper to the members, is to call attention to the rules usually adopted for discounting deferred values. The absurdly low present values given by tables calculated at compound interest, when high remunerative rates of interest are necessary and the deferred period exceeds a few years, induced the writer to investigate the matter, and he concluded that the customary method of determining the present value was not sound. Were it not that the writer's independent conclusions appeared to agree with those laid down by an eminent actuary, he would have had some hesitation in presenting his views. He has thought it desirable to give, at the same time, a résumé of the subject generally.

The valuation of a mine or a mineral estate presents unusual difficulties as the special risks to which the revenue are subject and the peculiar character of the property necessitates the application of certain principles not common to the valuation of other properties. The work which a mining engineer, engaged on a valuation, has to perform is twofold: the first part depends for its worth on the ability and experience of the engineer, and the second part on the accuracy of the actuarial principles applied to determine the value.

General Procedure.—The valuer first estimates the annual revenue that may be derived from the property, and the number of years during which this revenue may be expected to be realized. He next decides upon the rate of interest, which, after due regard to the character of the property, he considers a suitable return for the risk, and then he is in a position to estimate the present value. It follows that, at the end of the term of years fixed for revenue, a mineral estate may be taken as value-

less. A colliery may be treated practically in the same manner, for the plant at breaking-up prices cannot have much present value; and apart from this there are usually obligations to be performed on the termination of the lease, such as the restoration of the surface and other lessee's covenants, and this may be left to cover them. Should, however, the engineer consider that the plant at the end of the term would have an appreciable value in excess of the obligations due to the lessor, the present value of such sum must be calculated and taken into consideration in the purchase money.

Redemption of the Principal.—In estimating the present value, it is necessary that the annual revenue should be such as not only to afford the specified interest on the principal, but such additional sum as will enable a purchaser to redeem his original capital. The amount to be reinvested should be large enough to redeem the principal, by a safe investment, which would yield an absolutely certain income as a trust security, and should not be calculated at the high rate of interest, which the risk of a mineral property necessitates for reasonable investment.

Accumulative and Remunerative Rates of Interest.—The positive accumulative rate of capital is fixed by the increments due to the interest that can be obtained from an investment, in which the principal and interest are absolutely secure. Theoreti- [redacted]

this country, calculated over a long period of years, was not more than 3 per cent., after allowing for redemption of capital. He supported his statement by more or less authoritative figures, and while his estimate of profits was perhaps low, the error must be small.

The rate of interest to be calculated as the basis of a speculative transaction is divisible into two parts:—(1) Interest at the accumulative rate, which is the actual earning power of the principal; and (2) interest or insurance for the risk taken. It follows, therefore, that a speculation which yields anything greater than this accumulative rate has been successful, no matter how much it falls short of the rate calculated as the basis of the purchase.

The remunerative rates of interest adopted for the valuation of mineral properties vary between wide limits. For coal-mines in this country, the rate of interest generally ranges from 6 to 15 per cent. A thorough knowledge of the circumstances and experience of similar transactions can alone enable the mining engineer to fix, with any degree of accuracy, the rate of interest on which he should base his calculations so as to obtain equitable results.

Valuation of Mineral Estates.—Frequently a valuation has to be made on the slenderest foundation, and it is not surprising if the estimate be often very wide of the realized price. Take the case of a mineral estate, which can only be worked to a profit by an adjoining colliery. The gross royalty value of the minerals at current prices can be estimated with more or less accuracy; but, if a revenue be not assured by a lease of the mines to the colliery company, an estimate based on a probable prospective revenue may be entirely at fault. Competition generally decides the value of a commodity; but, in this case, there is practically no competition, the ultimate purchaser of the coal must be the colliery company, and they must be depended upon for the revenue. It is, therefore, in their power to dictate terms; and, in the event of these being refused, they can render the estate valueless by leaving the minerals unworked. It is improbable that such an extremity would be resorted to, for if the mines were offered on reasonable terms it would be to the interest of the colliery owners to accept them.

But what is more frequently done, when a difficulty about terms arises, is to defer the working of the mines for some time, and, as a consequence, to depreciate their present value. A valuation under such circumstances cannot claim to be precise; but this objection applies more or less to all valuations based on high remunerative rates of interest, for the use of a high remunerative rate presupposes uncertainty as to the realization of profits.

Valuation of Collieries.—To form an opinion upon the value of a colliery, the engineer requires an estimate of (*a*) the total quantity of workable coal available, (*b*) the annual output, (*c*) the annual profits, (*d*) the value of the plant, etc., at the end of the term, and (*e*) the cost of fulfilling all obligations at the end of the term. Innumerable points arise for consideration before any satisfactory estimate can be made. To obtain the total quantity of coal available for sale, proper allowance must be made for colliery-consumption, faults, barriers and pillars which will be required to be left for support: all seams must be included, which it is thought may be workable to a profit during the term, although it may be deemed advisable to divide the total life of the colliery into two or more periods, so as to differentiate the profits according to the quality of the seams likely to be worked in each period, and the probable cost of getting. The estimate of the annual output may be conditional on the expenditure of a certain sum in development, and this must be allowed for when determining the present value of the [redacted]

royalty payments on abandoned coal, and other costs incidental to winding up.

The original capital may be reduced by the amount recoverable at the end of the term to ascertain the sum which has to be redeemed by the sinking fund; or a sinking fund may be allowed for, large enough to redeem the original capital, and the present value of the recoverable capital may be calculated at a practicable rate of interest. Theoretically, the latter method would be more advantageous to a purchaser, for the sinking fund would be taken at an accumulative rate of interest and the present value of the recoverable capital would be taken at a slightly higher rate. In practice, however, there would be little difference, for the valuer would be inclined to estimate the recoverable capital at the minimum, if it were accounted as redeemed capital; and would make a more generous estimate if it were to rank as profits.

Discounting Deferred Values.—In the case of a mineral estate from which there is no immediate revenue, the engineer, with a knowledge of the circumstances, forms an estimate of the period which must elapse before revenue commences; and, having fixed the probable annual revenue and its term, calculates the present value on the basis of a deferred annuity. This method is generally followed, but there appears to be a diversity of opinion as to how the interest accumulating during the deferred period should be calculated. The general custom appears to be to base the valuation on the principle that compound interest, at the high rate stipulated for the purchase, should be allowed during the deferred period; and that interest at the high rate should be allowed during the period of revenue on the amount thus accumulated. This stipulation, in the writer's opinion, is erroneous, and cannot be accepted as yielding equitable results. The purchaser of a deferred annuity must be placed in no better and in no worse position than if his purchase were an immediate annuity. The method given above puts a purchaser in a much better position, as is obviously shown when the remunerative rate of interest is high and the deferred period is a long one.

To take the problem in its simplest form, say it is required to find the present value of a sum of money due some years hence. If the rate of interest agreed upon as the basis of

the transaction be what may be termed a "practicable" rate, the present value should be such as would accumulate at compound interest, at the end of the deferred period, to the money due. Should, however, a high rate of interest be stipulated, the purchaser anticipates interest at that rate on his principal, but the accumulations of interest cannot be expected to acquire interest at the high rate: because the interest is not capital risked by the purchaser, and is therefore not entitled to insurance, but should acquire interest at a practicable rate.

It may be argued that it is entirely a matter of arrangement; and that the purchaser, knowing the method to be adopted, stipulates for a remunerative rate of interest accordingly. Practically, if the parties to the transaction were able to accurately gauge the conditions, so as to afford comparison with some standard, it would be of no great consequence which method was adopted. The writer, however, is of opinion that to stipulate for compound interest, at a high remunerative rate, is illogical; and that it affords no true basis for comparison and is misleading.

Say, a purchase is made on a 10 per cent. basis. Taking the purchase money as £100, if the investment proves as successful as is anticipated and the interest is realized annually, the purchaser obtains a profit of £10 each year. He may use the profits to purchase gilt-edged securities, in which case he would obtain, say, 3 per cent. on them; or he may speculate again for a 10 per cent. rate of interest. If the second course were followed and proved successful, he would have obtained 10 per [redacted]

year, but that the transaction is successfully closed at the end of the second year, the purchaser is entitled to 10 per cent. interest during the second year on the accumulative amount of his principal, that is to say, 10 per cent. on £103, together with the £10 due for the first year, or, in all, including principal, £120·3; but if interest be paid at the high rate on the accumulative amount of the principal during the second year he is not entitled to any interest on the £7, the amount of the insurance to cover the risk. The purchaser risks the amount of the principal at the accumulative rate, but the £7 is part of the money for which he has speculated, and, whether the purchaser obtains the whole or part of it, depends upon the success of the speculation. It cannot be assumed that this money ranks as capital and is invested in the speculation.

If a man effect a speculation which is to be closed on the same day, his possible loss is limited to his purchase money; and it would be absurd to allow him to increase his shares, in the event of the speculation being successful, by adding to it any portion of the money gained in the speculation. Similarly, the £7 is not money risked, nor is it part of the natural accumulative value of the principal; and to calculate interest at the high rate on this amount would be equivalent to giving the purchaser the option of increasing his shares if the speculation were successful, while limiting his losses in the event of failure.

The investor must increase his holding to the extent of the natural increase of the capital at the accumulative rate, but it is not logical to assume that the extra interest, for which the speculation is made, can be invested in the transaction to acquire interest at the remunerative rate. Whether the calculation be based on the assumption that the profits are realized annually during the deferred period and invested to acquire interest at the accumulative rate, or that the remunerative rate of interest is to be allowed on the amount of the capital increased at the accumulative rate, is immaterial, as both methods are logical and the results are identical. The former method is the way in which the problem is viewed by Mr. George King,* who appears to consider it as axiomatic that the profits must be calculated as accumulating at the lower rate of interest. A consideration of the operations of the fund by each method for a number of years will be instructive.

* *The Theory of Finance*, by Mr. George King, third edition, 1898, page 38.

Let it be required to find what sum should be paid four years hence in consideration of a present advance of £100, the remunerative rate of interest being 10 per cent. and the accumulative rate 3 per cent.

(*a*) By the first method, taking the profits as accumulative:

Principal		£100·00000
First year's interest		10·00000
Second year's interest:		
10 per cent. on the principal	£10·00000	
3 per cent. on the previous year's interest ...	0·30000	
		10·30000
Third year's interest:		
10 per cent. on the principal	£10·00000	
3 per cent. on the accumulated interest, £20·30000	0·60900	
		10·60900
Fourth year's interest:		
10 per cent. on the principal	£10·00000	
3 per cent. on the accumulated interest, £30·90900	0·92727	
		10·92727
The amount due at the end of four years being		£141·83627

(*b*) By the second method, taking the accumulative amount of the principal and allowing interest at the remunerative rate on that amount:

Principal	£100·00000
First year's interest	10·00000
Second year's interest: 10 per cent. on the accumulative amount of the principal, £103	10·30000
Third year's interest: 10 per cent. on the accumulative amount	

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actions, the interest is generally stated in rate per cent, but for mathematical calculations it will be found to facilitate operations if the interest be converted to rate per unit. Whereas the commercial custom is to give the interest on 100, the interest is required on unity; and the rate per cent. must, therefore, be divided by 100 to obtain the rate per unit. The sum of any principal and its interest together is called the amount.

If the interest on a loan be calculated on the principal only, for the whole time of the loan, it is said to be simple interest. If the principal be increased at fixed periods by the interest then due, and the interest for each succeeding period be calculated on the original principal together with the previous accumulations of interest, it is termed compound interest.

Unless otherwise stated, the unit of time for the calculation of interest is one year, and when compound interest is stipulated for, the interest is convertible, that is to say, it is added to the principal each year. Strictly speaking there is no such thing as simple interest, for interest due must have an accumulative value. What is meant, when simple interest is made a conditional term of a loan, is that the period at which interest becomes convertible is for some longer period than one year. In such a case the annual rate of interest is stated, but it is the nominal rate of interest that is given and not the effective rate. Thus, if the conditions of a loan were 5 per cent. per annum simple interest for three years, the 5 per cent. is the nominal rate of interest and it would be more correct to say that the rate of interest was 15 per cent. per three years, the word "simple" being deleted. Similarly, it frequently happens that a loan is made for compound interest with the condition that the interest is to be convertible at shorter periods than one year. In such a case, the nominal rate of interest per annum is less than will be actually realized. Thus, say, the conditions of a loan are 5 per cent. per annum and the interest is to be paid half-yearly, here 5 per cent. is the nominal rate of interest, for if half a year's interest be paid each half year, the actual interest paid is greater than 5 per cent. per annum: for the first half year's payment of interest in any one year may be invested, and interest acquired thereon during the second half of the year. The conditions would have been more correctly stated by fixing the rate of interest as 2½ per cent. per half year.

For purposes of distinction, the rate of interest which can be obtained on capital invested with a minimum of risk is termed the accumulative rate, and when a higher rate of interest is stipulated to cover risk it is termed the remunerative rate.

Annuities.—An annuity is a periodical payment amounting to a certain annual sum. The term or status of an annuity may be a fixed number of years, when the annuity is termed certain, or for an uncertain period to be determined by a particular event. An annuity that is to be paid indefinitely is termed a perpetuity.

The first payment of an annuity payable annually is assumed to become due at the end of the first year for which the annuity is made, and in the case of a deferred annuity, payable annually, the first payment is assumed to become due one year after the period of deferment. Similarly, if the payments of an annuity have to be made at more frequent intervals than one year, the first payment is assumed to become due at the end of the first period of the term for which the annuity is made.

If it be required that the first payment of an annuity be payable at the beginning of the term, it is called an annuity due.

Redemption or Sinking Fund.—The terms of purchase of an annuity certain must be such that the annuity will provide not merely interest on the outlay at the stipulated rate, but also such additional sum, as will, if invested as obtained, amount

[redacted]

fact that a portion of the principal is redeemed each year of revenue. Theoretically, the annuity should provide interest at the stipulated rate on the outstanding capital only. As, however, a purchaser makes his bargain on the assumption that the annuity will provide interest at the specified rate on his original outlay during the whole of the term, this is the principle adopted in the formulæ and is the one universally accepted.

Rules and Examples.

I.—*The amount of £1 in n years.*—If the principal be £1 and the interest be at the rate of r per £ per annum, the amount to which the principal accumulates in one year will be $1+r$, and if this amount be invested for another year at the rate r, its amount at the end of the second year will be $(1+r)(1+r)$ or $(1+r)^2$; and, generally, £1 invested at the rate r, compound interest, for n years, will amount to $(1+r)^n$.

Where r is the rate of interest, or interest on 1, or rate per cent. divided by 100; n, the term of years; and R^n, the amount of 1 in n years at the rate r; then: $R^n=(1+r)^n$ . . . (1)

(*a*) *Example.*—What is the amount of £1,000 in eight years at 4 per cent. compound interest? The rate, r, equals 4 divided by 100 or 0·04; and the amount of 1 equals $(1+0{\cdot}04)^8$ or $1{\cdot}04^8$ or 1·368569. The amount of £1 at 4 per cent. in eight years is consequently £1·368569, and the amount of £1,000 is £1,368·569.

If the interest is to be calculated for a unit of time other than one year: that is to say, if the interest is to be convertible at greater or less frequent periods than one year, the same principle holds. Thus, say, the interest is realized m times per year, the interest for each unit of time being r/m (where r is the nominal rate of interest for a year). Then the amount of £1 in one year is $\left(1+\frac{r}{m}\right)^m$, and the amount of £1 in n years is $\left(1+\frac{r}{m}\right)^{mn}$. (1*a*)

(*b*) *Example.*—What is the amount of £1,000 in eight years at 4 per cent. per annum, the interest being convertible half-yearly? It should be noted that 4 per cent. per annum is the nominal rate of interest, the actual rate of interest being 2 per cent. per half year. The rate, r, equals 0·04, m is 2, and $\frac{r}{m}$ is 0·02. The amount of £1 for eight years is $(1+0{\cdot}02)^{2\times8}$ or $1{\cdot}02^{16}$, and $1{\cdot}02^{16}$ equals 1·372785. The amount of £1 in eight years is £1·372785, and the amount of £1,000 in eight years is £1,372·785.

It is obvious that 4 per cent. per annum, convertible half-yearly for eight years, amounts to the same as 2 per cent. per year for sixteen years.

II.—*The amount of £1 per annum in n years.*—As the first payment of an annuity becomes due at the end of the first year, the amount of an annuity of 1 at the end of the first year is 1; at the end of the second year, the annuity amounts to $1+(1+r)$; at the end of the third year, to $1+(1+r)+(1+r)^2$; and, generally, the amount of the annuity of 1 in n years equals $1+(1+r)+(1+r)^2 \ldots + (1+r)^{n-1}$ equals $\dfrac{(1+r)^n-1}{r}$.

Where r is the rate of interest or interest on 1; and R^n, the amount of 1 in n years at the rate r or $(1+r)^n$; then the amount of 1 per annum in n years equals $\dfrac{R^n-1}{r}$ . . . . . (2)

(*a*) *Example.*—What is the amount of £100 per annum in eight years at 4 per cent? The rate, r, is the interest on 1, or 4 divided by 100 equals 0·04. The amount of 1 equals $\dfrac{1{\cdot}04^8-1}{0{\cdot}04}$. As before, $1{\cdot}04^8$ equals 1·368569. The amount of 1 equals $\dfrac{1{\cdot}368569-1}{0{\cdot}04}$ equals $\dfrac{0{\cdot}368569}{0{\cdot}04}$ or 9·214225; and the amount of £100 per annum equals £921·4225.

If the annuity be payable by equal instalments m times in a [redacted]

invested at the rate, r, will yield an annuity of r indefinitely. Therefore the value of a perpetuity of 1 is $\frac{1}{r}$ . . . . (3)

The value of a perpetuity of 1 at 4 per cent. is 1 divided by 0·04 or 25.

IV.—*The value of a deferred perpetuity.*—A principal of 1 invested at the rate, r, will amount in n years to R^n; and if this be invested it will yield $r \times R^n$ indefinitely.

Therefore, where r is the rate of interest or the interest on 1 for one year; n, the number of years that the perpetuity is deferred; and R^n, the amount of 1 in n years at the rate r, or $(1+r)^n$; then the value of a perpetuity of 1 deferred n years is $\frac{1}{r \times R^n}$. (4)

(*a*) *Example.*—What is the value of a perpetuity of £10 deferred four years at 4 per cent? The rate, r, equals 4 divided by 100, equals 0·04; and R^n equals $1{\cdot}04^4$ or 1·16986. The value of a deferred perpetuity of £1 is $\frac{1}{0{\cdot}04 \times 1{\cdot}16986}$ or $\frac{1}{0{\cdot}0467944}$ or 21·3701; and the value of a deferred perpetuity of £10 is £213·701.

V.—*The present value of £1 due n years hence.*—It has been shown that a principal of 1 invested at the rate, r, for one year amounts to $1+r$; and, consequently, 1 is the present value of $1+r$ due one year hence. Therefore the present value of 1 due a year hence is $\frac{1}{1+r}$. Similarly, as $(1+r)^n$ is the amount of 1 in n years, it follows that 1 is the present value of $(1+r)^n$ due n years hence.

Where r is the rate of interest or the interest on 1 for one year; n, the term of years; and R^n, the amount of 1 at the rate, r, in n years, or $(1+r)^n$; then the present value of £1 due n years hence is $\frac{1}{(1+r)^n}$ or $\frac{1}{R^n}$ . . . . (5)

(*a*) *Example.*—What is the present value of £600 due eight years hence, at 4 per cent. per annum? The rate, r, equals 4 divided by 100 or 0·04. The present value of £1 equals $\frac{1}{(1+0{\cdot}04)^8}$ or $\frac{1}{1{\cdot}04^8}$ or $\frac{1}{1{\cdot}368569}$ or 0·73069; and the present value of £600 is £438·414.

The above rule is correct only when the rate of interest taken as the basis of the calculation is approximately the accumulative rate. If the nature of the transaction be such that a high rate of interest has to be allowed for remuneration, the rule ceases to give equitable results. The principle on which the calculation must be based is to place the purchaser of the deferred payment in the same position at the end of the term as that in which he would be if he had invested his capital in operations involving the same element of risk as the deferred payment and yielding interest annually. Assuming that such operations were successful, he would have realized the remunerative rate of interest on his capital each year, and these profits could be invested as obtained, so as to increase at an accumulative rate.

If s be the remunerative rate of interest and r the accumulative rate, the amount of s per annum in n years, by rule (2) is $s \times \frac{R^n - 1}{r}$. Taking the principal as unity, to find the amount of the principal, under these conditions, 1 must be added to the amount of the interest. Thus the amount of 1 in n years is $1 + s \times \frac{R^n - 1}{r}$. The reciprocal of this expression gives the present value of 1 due n years hence. Therefore, where r is the accumulative rate of interest; s, the remunerative rate of interest; R^n, the amount of 1 in n years at the rate r or $(1+r)^n$; then the present value of 1 in n years is

$$\frac{1}{1 + s \times \frac{R^n - 1}{r}} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

[redacted]

Where r is the interest on 1; and R^n is the amount of 1 in n years or $(1+r)^n$; then the redemption fund per annum that will amount to 1 in n years is $\frac{r}{R^n-1}$ . . . . . (7)

(*a*) *Example.*—What redemption or sinking fund must be invested annually at 3 per cent. to redeem £200 in 20 years? The amount R^n equals $1{\cdot}03^{20}$ or 1·806111. The redemption fund for 1 is $\frac{0{\cdot}03}{1{\cdot}806111-1}$ or 0·037216; and the redemption fund for £200 is £7·4432.

Should the interest on the redemption fund be invested m times per annum, and the interest be convertible m times per annum, the reciprocal of the rule (2*a*) must be applied. The redemption fund per annum, the interest being convertible m times per year, is $\frac{r}{\left(1+\frac{r}{m}\right)^{mn}-1}$ . . . . (7*a*)

(*b*) *Example.*—What annual sinking fund will amount to £200 in 20 years at 3 per cent.; the sinking fund being invested half-yearly, and the interest being convertible at the same intervals? The sinking fund for 1 is $\frac{0{\cdot}03}{\left(1+\frac{0{\cdot}03}{2}\right)^{20\times 2}-1}$ or $\frac{0{\cdot}03}{1{\cdot}015^{40}-1}$; $1{\cdot}015^{40}$ equals 1·814018; and $\frac{0{\cdot}03}{1{\cdot}814018-1}$ equals $\frac{0{\cdot}03}{0{\cdot}814018}$ or 0·036854. The sinking fund per annum to produce £200 is therefore £7·3708.

VII.—*The present value of an annuity.*—The amount of an annuity of 1 in n years was shown by rule (2) to be $\frac{R^n-1}{r}$. The present value of such an annuity must be such a sum as would, if invested at the rate, r, for n years, be equal to the amount of the annuity. Taking the present value as P, the amount of P at the rate, r, in n years equals $P\times R^n$; and $P\times R^n$ equals $\frac{R^n-1}{r}$.

Where r is the rate of interest, or interest on 1 for one year; n, the term of years; and R^n, the amount of 1 at the rate r in n years, or $(1+r)^n$; then the present value of the annuity, P, equals $\frac{R^n-1}{R^n\times r}$ . . . . (8)

(*a*) *Example.*—What is the present value of an annuity of

£100 for eight years, allowing interest at 3 per cent? The rate, r, equals 3 divided by 100 or 0·03; and R^n equals $1{\cdot}03^8$ or 1·26677. The present value of an annuity of 1 is $\frac{1{\cdot}26677-1}{1{\cdot}26677 \times 0{\cdot}03}$ or $\frac{0{\cdot}26677}{0{\cdot}0380031}$ or 7·0197; and the present value of an annuity of £100 is £701·97.

In the rule given above, the redemption fund is assumed to accumulate at the same rate of interest as is calculated on the principal. When a high rate of interest is taken as the remunerative rate on the principal, the rule will not apply, as the redemption fund could not be invested with safety to acquire interest at the same rate. Under such circumstances, it is necessary, therefore, to assume that the redemption fund accumulates at another and lower rate of interest.

Taking the present value of an annuity as P and the remunerative rate of interest allowed on the principal as s, the annuity must be such as will yield $P \times s$; and, in addition, a sufficient sum for the redemption fund such as will redeem the principal at a lower rate of interest, r. The redemption fund that will redeem P in n years was shown by rule (7) to be $P \times \frac{r}{R^n-1}$. Therefore, the annuity, P equals $\left(\frac{r}{R^n-1}+s\right)$; and for an annuity of 1, where s is the remunerative rate of interest on the principal; r, the rate of interest on the redemption fund; n, the term of years; and R^n, the amount of 1 in n years at the rate r, or $(1+r)^n$; then the present value, P, equals $\frac{1}{r}$ . . . . (9)

[redacted]

If the annuity be payable by equal instalments m times per year, and the interest be convertible at like intervals; where s is the nominal remunerative rate of interest per annum; r, the rate of interest per annum on the redemption fund; n, the term of years; and m, the number of times per annum that the instalments of the annuity are payable and the interest on the redemption fund is convertible, the present value of an annuity of 1 is $\dfrac{1}{\dfrac{r}{\left(1+\dfrac{r}{m}\right)^{mn}-1}+s}$. (9a).

(c) *Example.*—What is the value of an annuity of £100 for eight years, payable half-yearly, allowing a purchaser 10 per cent. interest and redeeming the principal at 4 per cent., interest on the redemption fund being convertible half-yearly? The rate, s, equals 10 divided by 100, or 0·10; r equals 4 divided by 100, or 0·04; m equals 2; $\dfrac{r}{m}$ equals $\dfrac{0{\cdot}04}{2}$ or 0·02; and $1{\cdot}02^{16}$ is 1·372786. The present value of an annuity of 1 is $\dfrac{1}{\dfrac{0{\cdot}04}{(1+0{\cdot}02)^{2\times 8}-1}+0{\cdot}10}$, or $\dfrac{1}{\dfrac{0{\cdot}04}{1{\cdot}372786-1}+0{\cdot}10}$, or $\dfrac{1}{0{\cdot}107300+0{\cdot}10}$, or 4·82392; and the present value of an annuity of £100 is £482·392.

An examination of the operations of the fund will show more clearly what the calculation allows. To redeem a principal of 1 by half-yearly investments at 4 per cent., with the interest convertible half-yearly, requires an annual sinking fund of $\dfrac{0{\cdot}04}{(1+0{\cdot}02)^{2\times 8}-1}$, or 0·107300. The redemption of the purchase money requires a sinking fund of $482{\cdot}392 \times 0{\cdot}107300$, or £51·76076; the provision of 10 per cent. interest on the purchase money requires £48·2392; making a total of £99·99996. The annuity of £100 therefore meets these conditions. It should, however, be noted that the £48·2392 provided by the annuity as interest on the principal, is payable by half-yearly instalments, therefore the actual rate of interest is 5 per cent. per half year, an effective rate of rather more than 10 per cent. per annum. The 10 per cent. is the nominal rate of interest, and is so defined in the formula.

VIII.—*The present value of a deferred annuity.*—As has been previously stated, when a high rate of interest is allowed on the

principal, the payments of the interest must be assumed to accumulate at another and lower rate. Where P is the present value of an annuity of 1, the amount of P and its accumulated interest at the end of a term of n years is $P\left(1+s\times\frac{R^n-1}{r}\right)$, where s is the remunerative rate of interest and r the accumulative rate of interest. The amount of an annuity of 1 for n years at the rate r was shown by rule (2) to be $\frac{R^n-1}{r}$. The amount of the principal and its accumulated interest at the end of the term should be equal to the amount of the annuity; and, consequently, $P\left(1+s\times\frac{R^n-1}{r}\right)$ equals $\frac{R^n-1}{r}$. This equation can be shown to be identical with the equation (9), giving the present value of an immediate annuity, which is as it should be, as the amount of the principal has been taken for exactly the same period as the term of the annuity. The problem which is under present consideration, however, is that of a deferred annuity, and if d be the period of deferment the expression becomes $P\left(1+s\times\frac{R^{n+d}-1}{r}\right)$ equals $\frac{R^n-1}{r}$; where s is the remunerative rate of interest; r, the accumulative rate of interest: n, the term of the annuity; d, the term of deferment; R^n, the amount of 1 in n years at the rate r, or $(1+r)^n$; and R^{n+d}, the amount of 1 in $n+d$ years at the rate, r, or $(1+r)^{n+d}$; then the present value, P, of a deferred annuity of 1 is

$$\frac{\frac{R^n-1}{r}}{\quad}$$

[redacted]

To show clearly the principle on which the formula has been constructed, the writer will assume that £330·25 has been invested under the conditions stated, and he will show that the operation of the annuity complies with the requirements;

Principal	£330·250
Interest at the rate of 15 per cent. on £330·250 equals £49·537, and £49·537 per annum for 10 years at 3 per cent. amounts to	567·892
The amount of the principal at the end of deferred period is therefore	£898·142
When the term of revenue commences:	
Interest at the rate of 15 per cent. must be provided on the outlay	£49·537
Interest at the rate of 3 per cent. on the amount of £567·892 to which the interest has accumulated	17·037
Redemption fund to produce £330·25 in 20 years at 3 per cent. ...	12·291
And there remains, to produce the £567·892 of interest accumulated during the deferred period	21·135
The total revenue being	£100·000

The sum of £21·135 per annum invested at 3 per cent. for twenty years amounts to £567·897; which practically agrees with the £567·892 required.

Prof. Henry Louis said that he thought that the views of the writer in regard to discounting deferred values were illogical. Mr. O'Donahue appeared to be of opinion that money invested to return interest a few years hence should receive what they might call a "risky rate" on the capital only, and the ordinary rate upon the interest. This would be perfectly sound, provided that one received the interest; but, when the principle was applied to a coal-mining proposition, it would be found that it did not apply at all, because the risk of not receiving the interest (or what was looked upon as ranking as such) was, at least, as great as that of losing the capital. He differed on this point from Mr. O'Donahue, as it seemed to him that the risk was fully as great during the preparatory period of sinking as during the period of working, and, therefore, anyone who invested his money before that time was entitled to the high rate of interest.

Mr. T. E. Forster said that there seemed to be as many opinions and as many theories on this subject as there were stars

in the sky, but the only principle that would pass the authorities of Somerset House, was the principle laid down by Mr. George King.*

Mr. T. A. O'Donahue, replying to the discussion, wrote that he quite agreed with Prof. H. Louis that the risk is as great during the deferred period as during the period fixed for revenue, and his rule is based on that assumption: the rate of remuneration allowed during the deferred period being identical with that of the annuity-term; and his argument is that it should not be greater. Prof. H. Louis stated that the method "would be perfectly sound, provided that one received the interest." Were the revenue assured, there would be no justification for a high remunerative rate of interest; and therefore the principle could not be sound with such a condition. Mr. T. E. Forster should not be taken seriously in his reference to the stars—the fingers of one hand would have afforded a better simile. So far as he was aware, there were not more than three theories on the subject which could be put forward with any reason; and he did not know of any that had been published except the two dealt with in his paper. The Somerset House test is certainly a criterion of the practical utility of the rule, though it is not necessarily a convincing one of its logical accuracy. He had, however, good reason to believe that the principle laid down was acceptable to the officials of the Estate Duty Office; but, to make the matter more certain, he submitted his views to the Secretary. [redacted]

identical results with that given by Mr. King. He had, however, retained the elementary values for the factors, so as to enable the mining engineer to apply the rule more easily. He desired to make it clear, although Mr. King had deduced a rule to comply with certain conditions, that he was not disposed to say that the particular conditions premised were alone permissible; in fact, Mr. King stated that he had but little experience of the problem, as it was outside his own special sphere, and was of the opinion that the conditions should be decided by mining experts. On the other hand, he (Mr. O'Donahue) contended that the principle laid down was the correct one from which to obtain equitable results, and the Somerset House authorities apparently held the same view.

Mr. EDWIN KENYON delivered a lecture on the "Transmission of Power by Ropes."

The PRESIDENT (Mr. J. H. Merivale) moved a vote of thanks to Mr. Kenyon for his useful lecture.

The motion was cordially approved.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT AXWELL PARK COLLIERY, SWALWELL, DECEMBER 5TH, 1906.

ELECTRIC PLANT, AXWELL PARK COLLIERY.

The machinery throughout Axwell Park colliery is worked by electric power, comprizing hauling, pumping, ventilating, winding, screening, disintegrating, elevating, etc.

The winder is employed especially for the raising and lowering of workmen at a shaft near the face of the workings, as the bulk of the coal is conveyed by rope-haulage through a drift some distance away. It comprizes an Ilgner motor-generator set, consisting of a three-phase motor of 33 horsepower at 550 volts, a variable-voltage generator of 23 kilowatts, an exciter of 2 kilowatts, and a flywheel, weighing about 25 cwts. These are all supported on one foundation-bed, connected by rigid and flexible couplings, and they run at 1,200 revolutions per minute. The bearings are arranged for oil-ring lubrication. The momentum of the flywheel would enable a complete wind to be made, after cutting off the supply of current to the motor. The winder [redacted]

similar to those generally used with Ilgner winding plants, except that the magnetic brake is also controlled by the speed-regulating handle. It is, therefore, quite impossible for the motorman to apply the operating brake, except when the controller-handle is in the neutral position; and, for the same reason, it is also impossible to start the winder before the operating brake is off. The speed can be controlled within 2½ per cent. of the maximum. By a suitable arrangement of cams fixed to the depth-indicator, the speed of the cage may be automatically reduced, and gradually brought to rest at the end of a wind, and thus prevent overwinding. Cams are also fitted to regulate the rate of acceleration at the commencement of each wind. It is further intended to fix a second controller inside the cage, so that the attendance of onsetters and banksmen will be unnecessary during the night shift. For this purpose, it is proposed to use a flexible cable suspended beneath the cage. By means of an automatic slip-regulator connected to the rotor circuit of the three-phase motor, the speed of the motor, and, consequently, of the flywheel, may be controlled within certain limits. Energy in excess of 33 horsepower is obtained from the flywheel, and it is again stored during the intervals between the winds. The maximum speed of winding is 8 feet per second; the depth of the shaft, 255 feet; the period of a wind, 40 seconds; and the interval, 15 seconds.

The car for loading the coke-ovens has a carrying capacity of 4 tons, it is equipped with a series-wound motor of 10 horsepower and a British-Thomson-Houston controller. The current is obtained from a trolley-wire suspended along the centre of each track. The car automatically opens and closes the hopper-slides when loading, and the car-driver can work the bottom-slides of the car by means of levers fixed to the footplate, and thus discharge the coal into the coke-ovens without leaving his position on the car.

The electric current is generated at the Blaydon station of the Priestman Power Company, from the waste heat of Otto-Hilgenstock coke-ovens installed at Blaydon Burn colliery. It is supplied to Axwell Park colliery in conjunction with the County of Durham Electric Power Distribution Company, Limited, at a pressure of 5,500 volts on the three-phase system, and it is transformed to a pressure of 550 volts for use at the colliery.

THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT, NOVEMBER 12TH, 1906.

MR. A. H. HEATH, RETIRING-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

HONORARY MEMBER—
Mr. H. JOHNSTONE, H.M. Inspector of Mines, Stafford.
ASSOCIATE MEMBER—
Mr. W. H. CORE, Withington, Manchester.

[redacted]

During the year general meetings were held in September, October, December, January, March and July, with excursion meetings in June and July.

The following papers were read during the year:—

"Notes on the Feed-water of Colliery Boilers." By Mr. A. E. Cooke.

"Presidential Address." By Mr. A. H. Heath.

"A Gob-fire in the Ten-feet Seam, North Staffordshire." By Mr. W. G. Peasegood.

The Council regret that only two members have come forward with papers during the year, and would welcome an increase during the current year. With this object in view they renew the offer of prizes, of the value of (*a*) £3 3s. and (*b*) £2 2s., for the best paper read at general meetings during the current year by (*a*) Members and Associate Members, and (*b*) Associates and Students.

In September, 1905, the Duke of Sutherland offered Trentham Hall to the County Council for the purposes of a college for higher education, but the representatives of the various bodies negotiating the matter concluded that the site near Stoke railway-station was more preferable on which to erect a suitable building. The present idea is to erect an institute on this site, and equip laboratories for mining, pottery, chemistry and physics, with suitable lecture and meeting rooms. The estimated cost is £12,000, and it is thought that the County Council would provide one-half the amount (£6,000) on the understanding that the remaining half is provided locally. Of this other half (£6,000), it is hoped that colliery-owners and the Mining Institute will raise £3,000, leaving £3,000 to be raised by pottery-owners and others. The amount in the bank at June 30th, 1906, to the credit of colliery-owners and the Mining Institute, was £1,257 16s. 10d., and a further sum of £413 10s. has been promised. Steps are now being taken with the view of raising the £6,000 locally, to enable the matter to be pushed to a practical issue.

The last session of the County Council Mining Classes was the most satisfactory ever held in North Staffordshire, the number of enrolled students being 435. The results of the examination were most encouraging. The prizes were distributed on December 9th, 1905, by Prof. T. Turner, and the gathering was in every way a success.

[redacted]

HE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS — CR.

FOR THE YEAR ENDING JULY 31ST, 1906.

	s.	d.	£	s.	d.
			147	8	9
	2	0			
	13	0			
	15	0			
	3	6	274	11	6
	5	0			
	12	0			
	18	11			
	5	6	10	1	5
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			£436	5	8

	£	s.	d.	£	s.	d.
July 31st, 1906.						
By the Institution of Mining Engineers :—						
Calls for 1905-1906, 141 at 19s. ...	133	19	0			
,, 1904-1905, 10 at 19s. ...	9	10	0			
Supplying *Transactions* to 5 members	5	0	0			
Excerpts	1	5	6			
Proportionate cost of exchanges	3	19	5			
				153	13	11
,, printing and stationery				18	5	10
,, annual dinner, exhibition, etc.				17	6	2
,, storage of books	1	1	0			
,, secretary's salary and expenses ...	71	14	3			
,, auditor's fee	2	2	0			
,, reporter's salary and expenses ...	13	0	0			
,, treasurer's postages, etc.	1	4	2			
,, fire-insurance premium	0	8	9			
,, removal of goods	0	3	0			
				89	13	2
,, library account				17	15	0
,, rent and hire of rooms				11	15	0
,, balance in bank				127	16	7
				£436	5	8

DR. THE TREASURER OF THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS FOR THE YEAR 1905-1906. CR.

	£ s. d.	£ s. d.
To 137 Members and Associate Members at £2 2s.	287 14 0	
,, 9 Honorary Members		
146		
,, 49 Associates at £1 6s.	63 14 0	
,, 28 Students at 15s. 6d.	21 14 0	
		373 2 0
223		
,, Subscriptions for the year 1906-1907, received this year	......	4 4 0
,, Arrears brought forward from 1905 ...	......	152 1 0
		£529 7 0

	Paid. £ s. d.	Unpaid. £ s. d.
By 99 Members and Associate Members paid, at £2 2s., *less* 4s. unpaid	207 14 0	0 4 0
,, 38 Members and Associate Members unpaid, at £2 2s.	......	79 16 0
,, 9 Honorary Members	......	......
146		
,, 23 Associates paid, at £1 6s.	29 18 0	......
,, 26 do. unpaid, at £1 6s. ...	......	33 16 0
49		
,, 20 Students, paid at 15s. 6d. ...	15 10 0	......
,, 8 do. unpaid, at 15s. 6d. ...	......	6 4 0
28	253 2 0	120 0 0
223		
,, Subscriptions for the year 1906-1907, received this year £4 4 0		
,, Arrears received this year 30 13 0	34 17 0	......
,, Arrears outstanding on July 31st, 1906	......	121 8 0
	287 19 0	241 8 0
		287 19 0
		£529 7 0

ANNUAL REPORT OF THE TREASURER, 1905-1906.

The Treasurer submitted the following statement of the accounts for the year ending July 31st, 1906:—

The total receipts amounted to £288 16s. 11d., of which £243 18s. 6d. is for current-year subscriptions, £30 13s. received for arrears, £10 1s. 5d. for sundries, and £4 4s. subscriptions paid in advance. It is with regret that the Committee have to report that, owing to a serious falling-off or laxity in the payment of subscriptions, the arrears for the year amount to £120, and, adding £121 8s. brought forward, there is a total of £241 8s. now owing.

The result of the year's working has been to decrease the credit-balance from £147 8s. 9d. at the end of the previous year to £127 16s. 7d. at July 31st, 1906. And in order that the Institute may be successfully carried on the Committee desire to impress on dilatory members the necessity of prompt payment of their subscriptions.

ANNUAL REPORT OF THE LIBRARIAN, 1905-1906.

The Librarian (Mr. F. H. Wynne) reported as follows:—

During the year, 41 volumes of transactions and publications of various societies and institutions have been bound, and added to the already valuable and extensive collection of literature relating to mining and allied subjects in the possession of this Institute. It is necessary again to point out the dis-

[redacted]

Mr. J. R. HAINES seconded the adoption of the reports, and the motion was carried.

Mr. JOHN NEWTON moved a vote of thanks to Mr. A. H. Heath for his services as President during the past two years.

Mr. J. C. CADMAN seconded the resolution, which was cordially approved.

ELECTION OF OFFICERS, 1906-1907.

The following officers of the Institute were elected for the ensuing year:—

PRESIDENT:
Mr. JOHN NEWTON.

VICE-PRESIDENTS:

Mr. J. R. HAINES	Mr. A. HASSAM.	Mr. G. P. HYSLOP.

TREASURER:
Mr. THOMAS ASHWORTH.

SECRETARY:
Mr. F. R. ATKINSON.

COUNCILLORS:

Mr. F. E. BUCKLEY.	Mr. J. HEATH.	Mr. J. MADDOCK.
Mr. W. G. COWLISHAW.	Mr. H. JOHNSTONE.	Mr. W. G. PEASEGOOD.
Mr. G. J. CROSBIE-DAWSON.	Mr. G. E. LAWTON.	Mr. J. T. STOBBS.
Mr. J. GREGORY.	Mr. W. LOCKETT.	Mr. F. H. WYNNE.

PRIZES.

Prizes have been awarded to the writers of the following papers:—

"Notes on the Feed-water of Colliery Boilers." By Mr. A. E. Cooke.

"A Gob-fire in the Ten-feet Seam, North Staffordshire." By Mr. W. G. Peasegood.

The PRESIDENT (Mr. John Newton) delivered the following "Presidential Address":—

PRESIDENTIAL ADDRESS.

By JOHN NEWTON.

I thank you most sincerely for the honour that you have conferred upon me by electing me as your President for the ensuing year. It is an honour which I much appreciate and value. I consider that the Institute of Mining and Mechanical Engineers is one of the most, if not the most, useful institution in North Staffordshire, having for its object the advancement of its most important industry, and the education, not only of the rising generation, but men of mature years. I think you will agree with me when I say that none of us are too old to learn, and that it is not only necessary to keep ourselves well informed as to new methods for advancing the science of our industry, but duly to consider the requirements of our various callings, and to endeavour, by an inter-communication of ideas, to encourage the introduction of fresh methods and the improvement of those already in existence.

I have one sincere regret in connection with my election today, and that is, a feeling of incapacity to fill the position as President of this Institute in the manner which its importance [redacted]

whole of the founders of the coal and iron industries of North Staffordshire. In fact, with two exceptions, our Presidents have been colliery managers: all of them, men of grit and perseverance, and mainly self-made men.

The North Staffordshire Institute of Mining and Mechanical Engineers was founded in December, 1872: 63 members being enrolled in that month. During the first year, until December, 1873, 100 members were enrolled, but only 7 of these original members are still with us. I think, with one exception, that the remainder have passed away. During the period which has elapsed since the formation of the Institute, we have had associated with our society all the men of note who have been connected with the coal and iron trades of North Staffordshire, in this generation, besides others, although not so closely allied with the district, yet whose connection with any Institute would at once stamp it as useful, and worthy of the consideration of all who have the welfare of their country at heart, and desire to see its trade and industries develop. Thomas Carlyle said "All true work is sacred; in all true work, were it but hand-labour, there is something of divineness," hence the appreciation of the labours of our best men who have been, and also those who still are, connected with the industry for which our Institute was founded, whose efforts are true work. I cannot, of course, in this address even mention the names of all deserving of appreciation, but to know that we have had such men connected with our Institute should spur us on to emulate them, so that in 30 years' time the younger members of to-day may be able to look back and view with satisfaction the progress that they have been able to make, and the advantage that they have taken of the opportunities which presented themselves.

Our first President was the late Mr. T. S. Wilkinson, and although, through misfortune, he was obliged to sever his connection with the coal trade, still he showed his appreciation of our Institute, and his desire for development and progress, by becoming the first President.

Our next President, the late Mr. Charles James Homer, was in many ways a most remarkable man. He was one of the founders of our Institute, and the position which we hold to-day is due

very largely to his energy and perseverance. He was born on August 17th, 1837. He was a pupil under the late Mr. William Forshaw at Lord Granville's collieries and ironworks (now belonging to the Shelton Iron, Steel and Coal Company, Limited) from 1852 to 1856, during which period rolling-mills and blast-furnaces were erected and the collieries and works considerably developed. In 1864, he became general manager of the Chatterley ironstone-mines at Tunstall. About 1868, Mr. Homer erected almost the first set of iron lattice-work pithead-frames, if not in the country, at least in North Staffordshire. At the time, these pithead-frames were very much appreciated by all the leading mining engineers of this country. In 1871, Mr. Homer promoted the formation of the Chatterley Coal and Iron Company, Limited, of which he became managing director. A private line of railway, over 2 miles long, was constructed to connect these collieries with the towns of Tunstall and Burslem. In 1871 and 1872, he constructed another railway, about 5 miles long, constituting a loop on the North Staffordshire Railway, and opening up the Adderley Green valley at Bucknall. This line became the property of, and is now worked by, the North Staffordshire Railway Company; the output of several important collieries is distributed by means of this route. In 1873, Mr. Homer became associated with the late Duke of Sutherland, Sir John Pender, and Mr. John Bourne, in the development of the mines of the Stafford Coal and Iron Company. This was virgin ground, and was held by some experts to be outside the North [redacted]

The late Mr. Daniel Adamson was our President from 1876 to 1878. He was a self-made man, but a born engineer, and after serving his apprenticeship made rapid progress towards that position of eminence, for which he was highly qualified and ultimately attained, in the engineering world. Those of us who had the pleasure of hearing his inaugural address on April 11th, 1877, will remember it as an intellectual treat. It was undoubtedly a great honour to have our Institute presided over by a man occupying so important a position in the engineering world, and one so much sought after because of his extraordinary ability and experience. He was also prime mover in the inauguration of the Manchester Ship Canal, and the success of that undertaking was largely due to his untiring energy.

Daniel Adamson was born at Shildon, Durham, in 1818, and in 1835 became a pupil of Mr. Timothy Hackworth—the first man who ever performed the functions of locomotive superintendent to a railway—at the Shildon works of the Stockton and Darlington Company. . . . . Mr. Adamson introduced many improvements in connection with his business, and was in the front rank for activity and enterprise. In 1852, he patented the flange-seam for high-pressure boiler-flues. . . . . He also patented improvements in the superheating of steam between cylinders of compound-engines, etc. In 1857 and 1858, he first applied steel in the construction of steam-boilers, and subsequently made more than 2,800 steel boilers for working at pressures varying from 50 pounds to 250 pounds per square inch. In 1858, he patented hydraulic lifting-jacks, and improvements in the application of hydraulic power for riveting metallic structures. During 1861 and 1862, he built a triple-expansion compound-engine, and in 1873, a quadruple-expansion compound-engine. . . . . In 1862, he commenced the making of steel boilers by drilling the rivet-holes through the two plates together after the plates are put into position. This method of drilling holes is now generally demanded in the practice of boiler manufacture. In 1863 and 1864, he erected the Yorkshire steel-works at Penistone, and was part owner of the first works in this country that depended entirely on the making of steel on a large scale solely by Bessemer plant. . . . . At the annual meeting of the Iron and Steel Institute on the 9th of May, 1888, while he held the office of President, Sir Henry Bessemer, at the request of the Council, presented to Mr. Adamson the Bessemer gold medal. Without in any way making an invidious comparison, Sir Henry said the unanimous decision of the Council to award the medal to Mr. Adamson met with his most cordial and entire approval. . . . . In 1863, Mr. Adamson patented improvements in converters for Bessemer steel. In 1863 and 1864, he introduced improved blast-engines for Bessemer blows. . . . . In official life, Mr. Adamson was a prominent figure. He was on the Commission of the Peace for the county of Chester, and was also a Magistrate for the city of Manchester. He was director of the Manchester Chamber of Commerce, in whose important functions he took great interest; and he was the President of the Iron and Steel Institute for 1888 and 1889, being one of the original members of that body.*

* *Minutes of the Proceedings of The Institution of Civil Engineers*, 1890, vol. c., pages 374-376.

The late Mr. John Strick was our next President, for the years 1878 to 1879. He was one of the original members. I think I may say that he was well known to us all, and held in the highest possible esteem. Although not demonstrative, the kindliness of his disposition and the constancy of his character appealed to all who knew him. He thus created a very large circle of friends. He took very great interest in our Institute, and did all in his power to extend its usefulness. Since his death, his widow has presented to the Institute all his technical works, which form a very valuable portion of our library and will preserve his memory in the minds of those who knew him, and will hand down his name to posterity.

Mr. W. Y. Craig was our President from 1879 to 1881, and during his presidency much good work was done: Mr. Craig himself contributing very valuable papers, besides imparting in other ways much useful knowledge. He at all times impressed upon the members the importance of mutual exchange of ideas, and in his inaugural address delivered on February 9th, 1880, he gave us some very sound advice as to what it is necessary to do and to study, in order to secure the best results from the human mind. Mr. Craig has been and still is a profound thinker; a large-minded man of very great experience. He never puts forth an opinion without having previously studied or thoroughly understanding his subject. He is of a kind disposition, slow to offend, but determined of purpose, and always [redacted]

large collieries in North Staffordshire, having acted as consulting engineer respecting them from time to time. He has also occupied a position as consulting engineer for the Cannock Chase, Westminster, Hanmer and Powell Duffryn collieries. He has also reported upon, and valued, some of the large collieries in Westphalia belonging to the Prussian Mining Company. With the late Mr. Joseph Cooper, Mr. Craig became owner of Podmore Hall colliery in 1870, and it was worked by them conjointly up to the time of Mr. Cooper's death in 1880. Mr. Craig then became sole owner, and worked Podmore Hall and Hayeswood collieries together until 1890, when they were sold to the Midland Coal, Coke and Iron Company, Limited. In 1870, the output at Podmore Hall colliery was 100 tons per day, and when it was transferred to the Midland Coal, Coke and Iron Company, Limited, the two pits yielded an output of 1,400 tons per day. I think such a record of work speaks volumes for the ability and untiring energy of Mr. Craig, whom we are so proud in being able to number as one of us.

The late Mr. John Brown was our President from 1881 to 1883. Mr. Brown's life and works gained for him the respect of everyone connected with the coal trade of North Staffordshire. His, too, was a name that brought credit to our Institute, and raised it in the estimation of all kindred Institutions in the country. He was a man of quick temper, and this at times was a cause of trouble to him. He began his technical education in the office of the late Mr. John T. Woodhouse, of Ashby-de-la-Zouche, and became an articled pupil in his office in the year 1848, subsequently acting as Mr. Woodhouse's principal assistant. In 1854, he commenced business on his own account in Barnsley. He was engaged along with Mr. Howell in a difficult investigation regarding Lord Granville's collieries in Staffordshire, and his extensive knowledge and accurate reports soon gained for him the confidence of a large clientèle. He was appointed engineer to the Lundhill Colliery Company after the disastrous explosion in this company's pit in 1857. He here introduced the dumb drift, a device whereby the gases coming with the ventilation-current from the workings were discharged into the upcast shaft at a higher level than the furnace, without coming into contact with it. Mr. Brown's consulting practice

was not confined to this country. He reported on mining projects in Denmark, Russia and Portugal. In 1869, he became engineer for the Cannock Chase Colliery Company, and was instrumental in developing that important coal-field. As early as 1852 he made the plans from which No. 2 pit of this field was constructed. Mr. Brown was afterwards appointed engineer to the South Staffordshire Mines Drainage Commissioners, and from 1874 to 1879 acted as consulting engineer to the Mid-Cannock Colliery Company. In 1880 he removed to Birmingham, where he continued and extended his consulting and arbitrating practice. Mr. Brown was elected a member of The Institution of Civil Engineers in 1858, he was a fellow of the Geological Society, a member of the Iron and Steel Institute, and numerous other kindred institutions in this country. His retentive memory, a strictly methodical system of working, a markedly judicial habit of mind in criticizing the cases laid before him, a frank and kindly manner, led to his being widely trusted in arbitration cases, and his advice in private enterprises was highly valued. Mr. Brown died on August 24th, 1888, in his sixty-fifth year, having been born at Stafford in 1823.

I cannot leave the subject of our past-Presidents without referring to the late Mr. William Heath. He was a man that we all knew, and I think I may safely say that he had the love and respect of all those with whom he came into contact. I had the pleasure of his friendship for almost forty years, and at times [redacted]

this did not prevent their continuing. They risked all, but the result has proved that their judgment was sound, for we all know that this colliery is now one of the best and most lucrative of our collieries in North Staffordshire.

There is a name among the oldest members of our Institute which stands boldly forward as one of the pioneers of the coal and iron trades of North Staffordshire. I refer to the late Mr. Robert Heath. He joined our Institute in March, 1874, and, although not an active member, he was foremost in the development of the coal and iron trades of this district. Mr. Heath did not, until late in life, take any part in public work. In fact, Mr. Heath was so engrossed with his own work, that he did not consider that he could spare the necessary time for the fulfilment of any public office. He was a believer in self. Mr. Craig's remarks when retiring from the presidency of this Institute, may be well applied to Mr. Heath, and I think are worth repeating. He said, "I can only say that I vacate this position with feelings somewhat of a mixed character. In the first place, I feel reluctant to recognize the fact that to-day terminates a period of official work during which, by your indulgence, by the opportunities which you have afforded me, and by the assistance you have ever given me, I have been able to be more useful to my fellow-men than I believed I could possibly have been, had I continued, as hitherto, to devote the whole of my attention to private affairs. We know it is quite possible—indeed it is a fact—that men not unfrequently give too little attention to private affairs, and that their minds are drawn from them by meddling with the business of other people, but there is also an error which may be committed in the opposite direction, and that is by devoting too much exclusive attention to private matters, and living in the world as if we were living entirely for ourselves. That, in my opinion, is a great error, and one valuable experience which I have gained during the two years I have presided over this Institute is this—that there is satisfaction and real value, considered both with reference to one's self and one's fellow mortals, in giving up some portion of time and some portion of one's means for the benefit of society."* Mr. Heath recognized this rather late in

* *Transactions of the North Staffordshire Institute of Mining and Mechanical Engineers*, 1881, vol. vi., page 5.

life: no doubt he would have enjoyed life better, and the community generally would have benefited had he done so earlier. *The Staffordshire Sentinel* of October 14th, 1893, published the following interesting biographical sketch of his life, which, I think, is worth quoting.

Mr. Robert Heath was born at Sneyd House, Burslem, on August 14th, 1816, and was consequently in his seventy-eighth year at the time of his death. His father, who bore the same name, was a mining engineer, of considerable attainments, and at this time held the post of manager of the Sneyd colliery. Mr. Heath was educated at Dr. Magnum's school, Etruria Hall, which he left when fourteen years of age to assist his father, who had taken over the management of the Clough Hall collieries for the Kinnersley family. Mr. Heath, senior, was in many ways a remarkable man, and this district owes much to his energy. *The Guide to the Iron Trade of North Staffordshire*, published in 1874, makes the following reference to him,—" In the development of the coal and ironstone resources of North Staffordshire the name of the late Mr. Heath must always be honourably identified. He it was who advised the Kinnersleys to open up the rich mineral property on their vast estate near Kidsgrove, where sixty years ago were erected under the same advice, the first ironworks in North Staffordshire." Mr. Kinnersley had the highest esteem for both father and son to whom in turn he entrusted the management of his works. Mr. Heath worthily deserved the title of a great captain of industry. His career was one long and almost unbroken series of successes, and the scope of his undertakings ever extended. To sketch his life as a business man is to give practically a history of the rise and development of the iron trade of North Staffordshire. His father, as manager of the Clough Hall works for Mr. Kinnersley, was one of the founders of the industry which now finds employment for so many thousands of hands. He built the first forge and mills in North Staffordshire, in 1838, and they were set to work by Mr. Heath, senior, in 1840. At that time there was a strong prejudice against pig-iron produced on the hot-blast system, and Mr. Kinnersley declined to [redacted]

was one of the largest and most important in the country, and it is said that to-day it is one of the most extensive and valuable undertakings owned by one family in England. Mr. Heath subsequently leased the mines at Norton from Lord Norton, then Sir Charles Adderley, and set up ironworks on a large scale. The lease of the Grange colliery, Cobridge, was acquired from Lord Camoys, and in 1867, the Ravensdale ironworks were purchased. Seventeen years later, Mr. Heath obtained the lease of the Brownhills colliery, Tunstall, from Messrs. N. P. Wood Brothers, and as recently as 1887, he took over the Brown Lees colliery, Biddulph, from the executors of the late Mr. Edward Kinnersley. Twenty years ago he purchased the freehold of the Biddulph estate, and has since enlarged it by the purchase of adjoining land. Mr. Heath retired from active participation in business in 1886, and the concern has since been carried on by his four sons acting in partnership. The firm, in the early part of the present year, took over the Kidsgrove pits, having previously acquired the Clough Hall estate from the representatives of Mr. Thomas Kinnersley, and disposed of part of the surface to the company now carrying it on as a pleasure-resort.

Another gentleman whose memory comes forcibly to my mind, while addressing you, who was a geologist, and, in fact, one of the cleverest men whom we have ever had associated with this Institute, that is the late Mr. Charles Eugene De Rance. During his life he accomplished much, but to the members of this Institute particularly, he was a source of pleasure and information such as very few men could be. He was a most courteous and polished gentleman, and we all think of his untimely end with sorrow.

There are many other names to which one would like to pay homage, would time permit. Among these, I may just mention our late courteous and indefatigable secretary, Mr. J. R. Haines, to whom was due, to a great extent, the energy and go that characterized the proceedings of this Institute in the early years of its existence, and for a period of over 25 years, Messrs. Thomas Ashworth, W. N. Atkinson, Jas. C. Cadman, A. M. Henshaw, Hugh R. Makepeace, A. R. Sawyer, F. Silvester, E. B. Wain, B. Woodworth, and others.

When one looks back at the early history of our Institute, and remembers with what determination and energy its proceedings were conducted, that is, before its federation with The Institution of Mining Engineers, one naturally enquires for the cause of its lethargy of to-day.

I shall have to appeal to our young men. They are our only hope, and I fully believe that if proper accommodation and

facilities were given them, we should not have to complain of the results. Something ought to be done, and at once, to house the mining students in a proper manner, and thus give them the opportunity of developing the knowledge that they have obtained at the elementary schools and continuation classes. The Bolton scheme ought to be pushed, and if, during my year of office, I can do anything to forward this project, I shall feel that my time has not been wasted.

Mr. A. M. Henshaw moved a vote of thanks to the President for his address.

Mr. G. P. Hyslop seconded the resolution, which was cordially approved.

THE COURRIÈRES EXPLOSION.

By W. N. ATKINSON and A. M. HENSHAW.

I.—Introduction.

On the morning of Saturday, March 10th, 1906, at a few minutes before 7 o'clock, an explosion occurred in the pits of the Courrières Coal Company (Compagnie des Mines de Houille de Courrières), Pas-de-Calais, France, which, in its appalling magnitude, overshadows all previous catastrophes recorded in the history of coal-mining. Eleven hundred men and boys lost their lives, and four pits were devastated.

Fig. 16.—Courrières Collieries, No. 2 Pit.

The explosion was attended by circumstances of intense human interest, and by phenomena involving questions of vital importance to everyone engaged in the industry of mining. The writers, who visited the collieries on two occasions after the explosion, spending 16 days underground, feel that they are fulfilling a duty in recording as fully as possible in the following notes, the facts and conclusions resulting from their investigations.

2.—Collieries.

The collieries of the Courrières Coal Company, comprizing fourteen pits, are situated some 60 miles south-east of Calais, near the town of Lens; and the importance of the undertaking may be realized at once from the facts that nearly 10,000 persons are employed in it and that the output exceeds 2¼ million tons of coal per annum.

The concession held by the Courrières Coal Company and granted by the State comprizes 13,489 acres (5,459 hectares), extending 5·8 miles (9,400 metres) from north to south and 3·7 miles (5,900 metres) from east to west. Operations were commenced in the year 1853 by the sinking of No. 1 pit, which is

[redacted]

the hooking-places, are of the following diameters:—No. 1 pit 11 feet 6 inches (3·50 metres); No. 2 pit, 12 feet 8 inches (3·85 metres); Nos. 3 and 4 pits, 14 feet 5 inches (4·40 metres); Nos. 5, 6 and 7 pits, 14 feet 9 inches (4·50 metres); Nos. 8 and 9 pits, 15 feet 1 inch (4·60 metres); No. 10 pit, 15 feet 5 inches (4·70 metres); and Nos. 11, 12 and 13 pits, 15 feet 9 inches (4·80 metres). Coal is drawn at nine of the shafts. They are generally partitioned at one side, so as to form a compartment in which ladders are placed (Fig. 3, Plate XVII.).

The horizontal winding-engines, of massive design and construction, have two cylinders and two drum-pulleys for flat ropes. The cylinders vary from 29·5 to 37·4 inches (0·75 to 0·95 metre) in diameter, and the stroke from 63·0 to 72·8 inches (1·60 to 1·85 metres). The engines, at the newer pits, are fitted with Reumaux controllers for automatically regulating the speed and for the prevention of over-winding.* The winding-engine at No. 13 pit has compound cylinders.

The boilers, numbering about 100, are of the semi-tubular type, and are generally worked at a pressure of 85 pounds per square inch (6 kilogrammes per square centimetre).

Ventilation is effected by fans of the Mortier, Guibal, Ser and Rateau types.

Air-compressing engines are installed at all of the pits; and at No. 13 pit the cylinders are two-stage. There are 17 compressors actuating about 160 hauling-engines, pumps, fans and drills underground.

There are elaborate and extensive screening arrangements, and at some of the pits the slack is washed and sold for the manufacture of coke.

The cages at the old pits have three decks, and carry two tubs on each deck. At the new pits, the cages have two decks carrying four tubs on each deck. The cages are usually fitted with automatic grips engaging with the guide-rods in the event of the rope breaking, and they are also fitted with detaching-hooks, which, upon coming into operation, suspend the cage and stop the engine by moving a valve.

The ropes are of aloes and flat, and the guide-rods are of oak.

Water is raised by cage-tanks and by pumps of the Worthington and Burton types.

* *Trans. Inst. M. E.*, 1892, vol. iii., page 1026.

The pit-tubs are well-built of steel, but some wooden tubs are still in use.

At the new pit, excellent bath-rooms are built providing accommodation for 150 men at one time.

3.—Coal-measures.

The Pas-de-Calais Coal-measures are entirely concealed below Cretaceous strata, in place of the Upper Carboniferous measures which have been denuded. The Chalk contains large quantities of water, and in sinking the freezing process is generally adopted. In the shafts, the water is kept back by tubbing of oak and sometimes of iron. Under the Chalk, there is a bed of impervious clay, which prevents the water from passing downward to the under-lying Coal-measures.

Table I.—Particulars of Working Coal-seams.

No. of Pits.	No. of Seams worked.	Quality of Coal.	Average Thickness.	Average Analyses.			Industrial Use.
				Fixed Carbon.	Volatile Matter.	Ash.	
			Ft. Ins.	Per cent.	Per cent.	Per cent.	
8 ...	8	Steam ...	2 8	77	11	12	Steam, domestic and briquettes.
7 and 9 ...	15	Coking .	2 10	68	24	8	Steam, puddling, coke and domestic.
2, 3, 4, 5, 6, 9, 10, 11 and	21	Gas ...	3 7	58	35	7	Steam, gas and domestic.

[redacted]

139 feet 9 inches (42·60 metres), the average thickness of those worked being 3 feet 3 inches (about 1 metre). In quality, the seams may be grouped as detailed in Table I.

The seams worked in the pits affected by the explosion were 10 in number and their names in descending order are as follows:—Julie, Mathilde, Augustine, Cécile, Ste. Barbe, Joséphine, Marie, Amée, Eugénie and Adelaide. In the southern part of the concession, where the folding occurs, the seams are duplicated, the upper series being found in reverse order.

5.—Systems of Working.

Owing to the faulted and contorted character of the measures and the great number of seams, the system of working presents special features. The usual custom of opening out is to drive north and south from each shaft, at vertical intervals of from 65 to 165 feet (20 to 50 metres), main cross-measure drifts or *bowettes* (Fig. 2, Plate XVII.). These drifts, which are of great length, cross the faults and undulating measures, intersecting the various seams at many points. From these intersections, level roads are driven east and west, and workings opened from them in the seams. In this way, a large number of separate districts are formed, more or less bounded by faults, but frequently extending to and joining the workings from other shafts. Communications are also established between the bowettes at different levels and with districts above or below, by vertical shafts or staples, of which there are a great number. These staples are generally of large size, fitted with cage and ladder compartments, and by their means the coal from different levels is lowered by gravity or raised by engines and brought to one hooking-place at each pit. Communications between districts, or recoveries away from the main bowettes, are made also by stone-drifts or *recoupages*. It will be understood how the system of working naturally lends itself to extension and intercommunication, and eventually to the joining-up of the different pits and seams right across the concession.

These communications, however, have not only been consequent upon the natural conditions and the system of working, but they have been rendered necessary as a means of ventilation by reason of the custom generally practised of sinking the shafts singly; thus Nos. 1, 2, 3, 7, 8, 9, 10 and 13 pits are all single shafts, whilst Nos. 4 and 11, 5 and 12, and 6 and 14 pits are

sunk in pairs or near together. All these shafts are connected underground. The systems of working adopted comprize pillar-and-stall, and longwall in stepped faces, either to the rise or on the level. The roads are large and well kept, and the excellent system of timbering is a special feature. This was, as will be remembered, the subject of a special investigation and report on behalf of the Home Office in 1901.* The Courrières Coal Company succeeded in reducing the death-rate due to falls, from 0·76 per 1,000 persons employed during the 10 years 1870-1879, to 0·15 per 1,000 persons employed during the 10 years 1890-1899. At the Mining Exhibition held in 1905, at Arras, the Courrières Coal Company was awarded a first prize for the excellence of its working and general arrangements.

Haulage is done principally by horses, compressed-air engines being used for descending places and for winding at staples. Ascending places are worked by gravity.

The coal is practically all worked by hand, but a few percussive machines of the Ingersoll-Sullivan or punching type are in use.

The system of ventilation appears to be elaborate and somewhat complicated, but efficient.

The plans accompanying these notes are not intended to show the details of the working-places, faces, faults or goaves. They show the main roads and principal workings only of the pits affected by the explosion.

6.—Fire-damp.

[redacted]

the deep from the 1,086 feet (331 metres) level. At the time of the explosion, 250 safety-lamps were in use in Nos. 4 and 11 pits, 90 in No. 2 pit, and a few in the Marie north-east headings at No. 3 pit.

The writers were informed by Mr. G. Léon, chief inspector of mines of the district, that since the explosion samples of air have been analysed, and tests made with the Chesneau lamp,* without revealing the presence of any fire-damp; and although, during the writers' inspection, the ventilation had not been restored, no trace of fire-damp was found by the ordinary benzine safety-lamp.

Generally speaking, the roadways and workings were dry and dusty, and no system of watering or other method of dealing with the dust had been adopted.

Little importance has been attached, hitherto, in France, to the dangers of coal-dust, it being held generally that without fire-damp coal-dust would not in itself produce or propagate an explosion beyond a comparatively short distance. In the Pas-de-Calais coal-field, explosions have been rare and of small extent.

7.—Explosives.

Blasting was freely resorted to for stone-work and coal-getting. The explosives are not submitted to any practical tests for safety as in Great Britain, but for use in mines producing fire-damp, or in dusty mines, the law requires that the explosive must conform to the conditions stated in a Ministerial circular, dated August 1st, 1890, as follows:—(1) The products of their detonation must not contain any combustible matter, such as hydrogen, carbon monoxide, solid carbon, etc.; (2) their temperature of detonation must be below 1,900° Cent. for work in stone and below 1,500° Cent. for work in coal. Each cartridge must bear a label indicating its composition, so as to enable the users themselves to verify the temperature of detonation according to a given formula.†

The composition of the explosives used in coal, at the Courrières collieries, were as follows:—(*a*) No. 1 Favier powder,

* "A Fire-damp Indicator," by Mr. G. Chesneau, *Trans. Inst. M. E.*, 1893, vol. iv., page 617.

† *Report of the (French) Commission on the Use of Explosives in the Presence of Fire-damp in Mines*, 1890, page 162.

nitrate of ammonium 88 per cent. and binitronapthalene 12 per cent.; and (*b*) grisounite-couche, nitrate of ammonium 95·5 per cent. and trinitronapthalene 4·5 per cent. The composition of the explosive used for stone-work was as follows:—Grisounite-roche, nitrate of ammonium 91·5 per cent. and binitronapthalene 8·5 per cent. No gunpowder was used. Grisounite-couche and grisounite-roche comply with the official regulations, and are regarded as "safety explosives." It will be seen that these explosives compare very closely with some of the British permitted explosives.

The explosives were supplied by the company, the cost being deducted from the miners' wages. The detonators were carried by appointed officials, and given out in the pit to persons requiring them. Where safety-lamps were in use, shots were fired electrically by an official; where naked lights were used, the miners fired their own shots by means of safety-fuse and detonators.

8.—Area affected by the Explosion.

Five only of the pits require particular attention as being directly concerned in the explosion, namely, Nos. 2, 3, 4, 10 and 11 (Fig. 1, Plate XVII.). These pits are situated in the southern part of the concession. Nos. 4 and 11 pits in the south-west are near together, No. 3 pit is a single shaft situated 3,900 feet to the east, No. 2 pit is a single shaft 4,200 feet farther to the east, and No. 10 pit is a single shaft, 1,500 feet to the south of No. 2 pit.

No. 11 pit was a winding and downcast shaft, its upcast shaft

No. 2 pit was a winding shaft and upcast for Nos. 3 and 10 pits.

No. 10 pit was a winding and downcast shaft, No. 2 pit being its upcast.

There were fans at Nos. 2, 3 and 4 pits.

9.—Fire in the Cécile Seam.

A fire, which had broken out underground a few days prior to the explosion, has been the subject of much comment; and it will be convenient, in relating the circumstances attending and following the explosion, to commence with this incident.

Between March 6th and 7th, 1906, smoke and smell from the fire were first noticed in a return-airway through goaf or old workings between the 919 and 1,070 feet (280 and 326 metres) levels in the Cécile seam near, and to the south-west of, No. 3 pit, Fig. 5 (Plate XIX.). It had been dealt with by the erection of stoppings in the roadways leading into and from the area affected: two stoppings being built on the lower or intake side, and five on the upper and return side. During the night of March 9th, Mr. René Petitjean, the company's principal engineer, was in the No. 3 pit superintending this work and saw the stoppings closed before leaving; Mr. Gabriel Barrault, the manager of No. 3 pit taking over the charge on the morning of March 10th. No danger appears to have been apprehended from this fire, and the pits continued working as usual.

10.—Explosion.

Table II. shows the number of persons ordinarily employed underground in all the pits of the company.

Table II.—Number of Workmen employed Underground.

No. of Pit.	Morning Shift.	Afternoon Shift.
1	1	0
2	563	212
3	539	161
4 and 11	768	292
5 and 12	702	210
6 and 14	813	292
7	679	305
8	282	80
9	642	287
10	529	260
13	24	48
	5,542	2,147

On the morning of Saturday, March 10th, 1,665 persons descended Nos. 2, 3, 4 and 11 pits, and everything appears to have proceeded as usual until a few minutes before seven o'clock, when the explosion occurred. The first intimation of the disaster at the surface was the emission of dense clouds of dust and smoke, accompanied by a loud report at Nos. 3, 4 and 11 pits. At No. 11 pit, the cage was thrown up towards the pulleys and disarranged, and some of the roof covering was blown off. At No. 4 pit, the covering at the top of the pit was blown open, but not damaged: one man working in the fan-drift was killed, but three others who were with him escaped. The damage at the top of No. 3 pit was chiefly at the landing-floor, but was not considerable. At No. 2 pit, the explosion caused no damage at the surface.

None of the three fans were damaged, and they all continued running.

11.—Rescue-operations and Reopening of Mines.

The officials and workmen immediately commenced the arduous work of rescue. Mr. Petitjean went to No. 3 pit, and quickly found that the fan was not exhausting from the mine, the ventilating compartment of the shaft having been destroyed. His first care was to attempt to restore the ventilation. He tried to descend, but finding it impossible to move the cages, he detached the rope of the lower cage and replaced the upper cage by a hoppet. On descending the shaft he found that the partitions, guides and ladders had been destroyed, completely

[redacted]

the 1,257 feet (383 metres) level, one man was found alive, and ten or twelve in the south bowette. Some 25 others were rescued from Nos. 4 and 11 pits during the day.

At No. 2 pit, the work of rescue was organized by the engineers, Messrs. P. Voisin and A. Pégheaire. Mr. Voisin fell asphyxiated in the cage, and his leg, which was outstretched, was broken; Mr. Pégheaire was also disabled by after-damp.

The work was courageously pursued by other officials and workmen, but at 7·30 a.m. No. 2 shaft became impassable, the shaft being filled with after-damp. The work of rescue was, however, continued from No. 10 pit.

Mr. Léon, the chief inspector of mines for the district, with his assistants, Messrs. Heurteau and Leprince-Ringuet, arrived at the colliery at an early hour.

Complying with article 14 of the decree of January 3rd, 1813, which makes it incumbent upon the State engineers to assume control in accidents of this nature, Mr. Léon immediately took full charge of the operations, descending No. 11 pit himself, and sending Mr. Heurteau to No. 10 pit, and Mr. Leprince-Ringuet to No. 3 pit. At 6 p.m., Mr. O. Delafond, inspector-general of mines, arrived from Paris. He descended No. 11 pit, and visited the other pits.

The work of rescue had been prosecuted meanwhile with great courage, and throughout the day many men and boys were brought out alive by Nos. 10 and 11 pits up to a late hour. At 9·30 p.m., 13 men were brought out from the hooking-place at 994 feet (303 metres) at No. 3 pit by way of No. 10 pit, and four others from the Julie road. At Nos. 4 and 11 pits, rescues were effected up to 10 or 11 p.m., when two members of a rescue-party lost their lives in trying to penetrate the south workings of the 1,086 feet (331 metres) level, from which quarter two men had just staggered to the pit. Thus, at the end of the first day, of the 1,665 men who descended Nos. 2, 3, 4 and 11 pits that morning, over 1,100 were still belowground, and the condition of the dead, found burnt, mutilated and asphyxiated, seemed to leave little hope of others being found alive.

On Sunday, March 11th, Mr. Léon ordered a further exploration of the workings of No. 3 pit by a party led by Mr. Leprince-Ringuet, accompanied by delegate-miner Simon, by way of Nos. 10 and 2 pits. At the same time, Mr. Domézon was continuing

the work at Nos. 4 and 11 pits by the aid of such feeble ventilation as could be obtained by repairing doors, though after-damp, coming from No. 3 pit, rendered the work extremely dangerous.

At 2 p.m., Mr. Leprince-Ringuet's party returned. They had again explored as far as the landing of No. 3 pit without result, and delegate-miner Simon expressed himself strongly that further search was hopeless.

The situation then was as follows:—At No. 3 pit, it was found to be impossible to remove the blockage and re-open the shaft in any reasonable time by ordinary means. During the first day Mr. Élie Reumaux, director of the collieries of the Lens Coal Company, had suggested blasting away the obstruction by dynamite, whilst other engineers proposed the dropping of a heavy weight to make at least a better passage for the ventilation and possibly for the hoppet. These proposals, however, did not meet with approval, and Mr. Petitjean, who had himself been working at the obstruction, considered that such measures would probably aggravate the difficulty by causing greater obstruction and possibly damage to the shaft itself. Mr. Petitjean, again descending, imagined he heard cries from the bottom. By this time he had cleared a passage down to a depth of 558 feet (170 metres), and now tried to pass a lamp and a written message through the débris to the men below. It was, however, quite impossible to do so. About this time, a rescue-party from No. 10 pit reached the hooking-place at a depth of 994 feet (303 metres), and found 13 men whose cries had been heard by Mr. [redacted]

Mr. Delafond therefore decided to reverse the ventilation by closing No. 11 shaft, closing No. 3 shaft and starting its fan, and transforming Nos. 2 and 4 pits from upcasts into downcasts.

It was thought that the reversal of the ventilation would not jeopardize the position of any men who, by a remote chance, might still be living in any *cul-de-sac* in the mine.

The change was made, and No. 3 pit fan was started on Sunday evening, March 11th. Some doubt was felt, however, as to whether the No. 3 pit fan would, in the blocked condition of the shaft, create a sufficient current of air from Nos. 2 and 4 pits, and towards Monday evening, March 12th, it was found that, notwithstanding the assistance from a water-fall, No. 4 pit still acted as an upcast.

It was therefore decided to continue No. 4 pit as an upcast shaft, and its fan was again set to work.

The position now was as follows:—The top of No. 11 pit, which had been a downcast and winding shaft, was closed. No. 4 pit was still an upcast. No. 3 pit was closed, and was now entirely an upcast. No. 2 pit was converted from an upcast shaft to be the sole downcast, and was now the only pit from which recovery-work could proceed.

On this day, March 12th, the Westphalian salvage corps, under the leadership of Mr. G. A. Meyer,* arrived from Germany; and a corps of fire-brigade men from Paris, equipped with oxygen-breathing apparatus of various types. They did not effect any saving of life, but their presence did much to restore confidence, and they did useful work in assisting to remove the bodies.

On Thursday, March 15th, a fire, presumably caused by the explosion, was discovered in the Joséphine seam, at a point, *a*, about 2,625 feet (800 metres) north-west of No. 2 pit (Fig. 7, Plate XXI.).

In the face of this new danger, and in the absence of water or other means of immediately attacking the fire, Mr. Delafond ordered the erection of three stoppings near No. 2 pit in the bowette, at 1,116 feet (340 metres), leading to the Joséphine seam, and one stopping in the bowette, at 1,004 feet (306 metres), leading to the Julie seam above the fire, from which level it was sus-

* "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party," by Mr. G. A. Meyer, *Trans. Inst. M. E.*, 1906, vol. xxxi., page 575.

pected that air might pass to the fire through the strata (Fig. 7, Plate XXI.). The erection of these stoppings closed the only remaining entrances to the workings of the pits affected by the explosion.

At a consultation held on March 17th, it was decided to make an attempt to master the fire, and accordingly the stoppings in the bowette, at 1,116 feet (340 metres), were replaced by iron doors, through which a range of water-pipes was laid. On the following day, the work of extinguishing the fire by water under pressure was commenced by direct attack, and by cuttings into and around the site of the fire. In this work, the Westphalian and Paris salvage corps did good service, dividing themselves into four parties with four men in each, equipped with respiratory apparatus.

The task of extinguishing the fire was under the direction of Mr. Fumat, Ostricourt collieries, who has had a large experience of underground fires, and had placed his services at the disposal of the Courrières Coal Company. On March 22nd, Mr. Paul Weiss was sent from Paris by the Minister of Public Works to assist Mr. Léon, and on March 27th, there being by that time a sensible diminution of the fire, the stopping in the bowette, at 1,004 feet (306 metres), was opened, thus re-establishing communication with No. 3 pit by way of the Julie level and the No. 3 pit bowette, at 919 feet (280 metres). The work of enlarging this road was taken in hand on March 28th and 29th.

The Westphalian salvage corps returned to Germany on [redacted]

of the time in a *cul-de-sac* to the south of No. 3 pit, where they escaped the after-damp; but they had wandered over many parts of the mine vainly trying to get out by the Joséphine and Ste. Barbe workings before their last and successful attempt by the Julie road. The two brave leaders of this party were decorated with the Cross of the Legion of Honour, and each man received a gold medal in recognition of his endurance.

Great consternation and excitement naturally followed this marvellous escape, as, contrary to all expectations, there even yet appeared to be a possibility of others still living in the pits. New explorations were immediately organized, and every accessible part searched with the utmost expedition; precautions, which prudence had dictated when only dead bodies were to be expected, being ignored.

During these two days (March 30th and 31st), nearly the whole of the workings of No. 3 pit were visited, and by April 1st, routes from No. 2 pit by No. 3 pit even to No. 4 pit, were travelled without finding any more survivors. Attention was also directed to Nos. 4 and 11 pits, and on March 30th, the day of the escape, the reopening of these pits was urgently desired; but, on the one hand, there was to be considered the risk of interfering with the ventilation of No. 3 pit, which it was so urgent to explore, and on the other hand, some repairs to the winding-engine, which had been going on during the time that the pit had been standing, were not completed. It was, therefore, not until the evening of April 2nd that the exploration of No. 11 pit was commenced. These explorations were particularly difficult, owing to the numerous and large falls, and the absence of ventilation.

On April 4th, the marvellous escape of another miner named Berthon has to be recorded. He had survived 25 days after the explosion, and was found close to Nos. 4 and 11 pits. Berthon worked at the face of the main west level in the Marie seam, at the end of the north bowette at a depth of 1,086 feet (331 metres). When the explosion occurred, he, with others of his comrades, tried to escape. Most of his comrades fell on the way to the pit, Berthon himself lost consciousness, but he eventually revived and returned to the face. He appears afterwards to have wandered about the main roads and in the neighbourhood of the pits, living on the food of his dead comrades. He was found in

a dazed condition, and did not seem to have realized his position, or the long time that he had been in the mine.

The exploration of Nos. 4 and 11 pits was vigorously pursued; but, owing to the difficulties encountered, progress was tedious and slow. On April 18th, an explorer, wearing an oxygen-apparatus with a helmet, was suffocated. He was supposed to have made too much exertion in passing over some falls, to have been out of breath, and to have removed his helmet.

The exploration of Nos. 4 and 11 pits was not completed until April 30th.

On June 26th, a second fire, *b*, was discovered in the Joséphine seam, north-east of No. 3 pit (Fig. 7, Plate XXI.). It was promptly dealt with by the erection of stoppings in its vicinity, eleven bodies being enclosed within the stoppings. One of the stoppings has since been opened and two bodies recovered; but, as the fire revived, it was necessary to rebuild it. A further attempt will shortly be made to extinguish this fire. It is believed that the two fires in the Joséphine seam were caused by the explosion.

12.—General Observations on the Cause of the Explosion.

Before proceeding to a detailed account of the effects of the explosion in the workings, the notes will be more clearly followed if the writers now state that the general result of their observations leads them to the conclusion that the destructive agent

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the whole of the workings of the four pits, fouling a large number of quite separate and independent workings and separate ventilating currents, including the main intakes even to the downcast shafts, in which roads the dynamic effects were particularly violent. It is difficult to conceive such a condition of things, and even an outburst of gas of the most sudden and extensive character in any one district could not possibly have spread over such an extensive and divided area of workings and brought about the conditions necessary to produce a fire-damp explosion of this magnitude.

Neither is it possible to conceive the occurrence simultaneously throughout the whole of the workings and intake-airways of even a small percentage of fire-damp, such as would with coal-dust produce an explosive mixture over the large area affected.

So far as the writers can judge, there is no evidence that can be brought to support the theory of so widespread an appearance of fire-damp. No alarm was raised before the explosion, and from the appearance of many of the victims and from the statements of the survivors, ordinary work was proceeding everywhere at the moment of the explosion.

An explosive medium must therefore be sought, which could and did exist over the whole area devastated. Such a medium is to be found in coal-dust, and, in the writers' opinion, coal-dust alone is sufficient to account for all the phenomena produced. Investigation has proved the existence of dry and inflammable dust throughout all the parts traversed by flames; and, on the other hand, numerous instances were observed where the explosion stopped on arriving at places where dust was either absent or of a very shaly nature, or where the roadways were sufficiently wet to prevent the further passage of flame fed by coal-dust. Deposits of charred and coked dust were plentiful in all parts of the mine traversed by the explosion, including intake-airways, thus affording good evidence of the combustion of dust. The dynamic effects of the explosion were coincident and co-extensive with this combustion and passage of flame.

In endeavouring to arrive at the cause and place of origin of the explosion, the usual practice was followed of noting the indications of the direction of force as shown by the projection of different materials and tracing those indications back to their common source.

13.—Theory of the Fire in the Cécile Coal-seam.

Before proceeding further, it will be well to discuss the fire in the Cécile coal-seam, as it was at first believed to have caused the explosion; and it has since assumed much prominence in various theories as to its furnishing fire-damp or inflammable gases produced by distillation of the coal.

As before stated, the roadways leading into and from the fire had been closed by seven stoppings, which were completed during the night previous to the explosion (Fig. 5, Plate XIX.). Nos. 1, 2, 3, 4 and 5 stoppings on the return side of the fire were built or faced with brickwork, and as the roads were in the solid coal of the shaft-pillar they were apparently good and tight. Nos. 6 and 7 stoppings on the intake side were built of dry stone and stowing, and were erected in goaf-roads.

After the explosion, No. 7 stopping, the outer one on the intake side, was found to be intact. There was no evidence of explosion at the stopping, but there was clear evidence that flame had traversed the level below and had gone into and up the rise goaf-road to within 100 or 120 feet of the stopping, where it ceased. Of those on the return side, Nos. 1, 4 and 5 stoppings were also intact, but Nos. 2 and 3 stoppings, brick-walls without any stowing, were blown down and the bricks projected inwards, thus suggesting that the force of the explosion had come from a district outside the stoppings. This view was afterwards confirmed by other indications found at the pit and at the staple near [redacted]

in the Cécile seam or in the workings of the Ste. Barbe or Joséphine seams lying below. The suggestion, therefore, that the fire in the Cécile seam played any part in the explosion may, the writers think, be dismissed. Not only was there no evidence to support this suggestion, but, on the contrary, there were abundant indications that the explosion came from another district and passed by the district of the fire, breaking down and blowing in Nos. 2 and 3 stoppings in its course.

14.—Effects of the Explosion.

Proceeding now to an account of the effects of the explosion in the roads and workings, the fate of the workmen and the tracing of indications, the writers commence with Nos. 4 and 11 pits. These pits are close together: No. 11 was a downcast and winding shaft, and No. 4 an upcast shaft only. They were connected with Nos. 3 and 5 pits, from each of which No. 4 pit drew certain splits of air. The main landing or hooking-place at No. 11 pit was at the 1,257 feet (383 metres) level, to which point, by north and south bowettes, and various staples, the coal was brought. At the hooking-place and the staples near the pit, 34 men and boys were burnt and killed, and 4 escaped.

Nos. 4 and 11 Pits.

In Nos. 4 and 11 pits, the following seams were being worked: —Cécile, Ste. Barbe, Joséphine, Marie, Amée, Eugénie and Adelaide; and they will be described in the same order.

Cécile Seam (Fig. 5, Plate XIX.).—Two small districts were being worked to the south-west at the levels of 981 feet (299 metres) and 1,086 feet (331 metres). The explosion did not reach these workings, but all the workmen were killed by after-damp. A question was raised as to whether 2 of these men (Sevin and Châtelain), in the 1,086 feet (331 metres) level, with others close by in the Ste. Barbe seam, had not lived for some time after the explosion. This point is referred to later, in the note on the report of the Carnot Commission (Appendix V.).

To the south-east of Nos. 4 and 11 pits were other small workings in the Cécile seam, at a depth of 981 feet (299 metres) with a communication to No. 3 pit. Some 15 men were killed

by after-damp, and the explosion in this road of communication was stopped near No. 3 pit for lack of inflammable dust (No. 13 analysis, Appendix I.).

Sainte Barbe Seam (Fig. 6, Plate XX.).—To the south-west, there were two districts at the 1,086 feet (331 metres) level. The explosion entered these districts by the south bowette and the Joséphine seam at the 1,086 feet (331 metres) level, but did not extend over the whole workings. Forty-three persons were killed. From the part reached by the recovery drift, two men, Broy and Delplanque, escaped late in the evening of the day of the explosion. They were found with Sevin and Châtelain, previously mentioned, who, with four others, were found dead and clothed, with their food-boxes and bottles empty. This matter will be referred to again later in the notes on the report of the Carnot Commission (Appendix V.).

To the south-east, there were other workings partly in the Ste. Barbe seam, and partly in the Ste. Barbe reversed seam, at the 1,086 feet (331 metres) and 981 feet (299 metres) levels. The men, 13 in number, were killed by the explosion in the 1,086 feet (331 metres) level, and by after-damp in the 981 feet (299 metres) level.

Joséphine Seam (Fig. 7, Plate XXI.).—This seam was worked extensively at the Nos. 4 and 11 pits, some 174 persons being at work. All were killed except five at the extreme end

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pit, and the north and south bowettes, at the 1,086 feet (331 metres) level, then by the north bowette to the Joséphine north-east district, and by the south bowette to the Joséphine south-east and south-west districts.

From the Joséphine south-east and south-west districts, there were three important connections, A, B and C, to the Joséphine airway leading to No. 5 pit, and, near these connections, Nos. 1 and 2 samples of dust were taken from the floor and sides (Appendix I.). The roads were not used for haulage, but only for travelling and ventilation, and the dust, of which there was not a large quantity, was mixed with stones and shale. The analysis of the fine portion screened through safety-lamp gauze shows that it was apparently too impure to be inflammable, and this fact undoubtedly saved No. 5 pit from disaster.

Marie Seam (Fig. 8, Plate XXII.).—Large districts were being worked to the north, south, east and west near Nos. 4 and 11 pits. The route of the explosion was clearly by the Joséphine communication from No. 3 pit, and the indications of direction were consistent with those already noted in the Joséphine workings. Flame reached the north and south bowettes at 1,086 feet (331 metres), and traversed all the Marie workings except those to the extreme north and a small separate district to the south at the deeper 1,257 feet (383 metres) level. All the men, 11 in number, from these lower Marie workings, and eight from the Marie north district, escaped or were rescued on the day of the explosion. The man Berthon, who escaped after living 25 days in the mine, worked at the extreme end of the last west level in the north district. About 126 persons were killed by the explosion, or died by after-damp in the Marie workings of Nos. 4 and 11 pits.

Amée Seam (Fig. 9, Plate XXIII.).—There were two districts, one to the north from the bowette at 1,086 feet (331 metres), and another to the south from the bowette at 1,257 feet (383 metres). The explosion reached the north district by the bowette at 1,086 feet (331 metres), and also by a staple from the Marie seam above. Flame could not with certainty be said to have traversed more than the main level, but of the 67 men employed only five escaped.

The Amée district to the south was at the lower level of 1,257 feet (383 metres), and there was a communication by a staple from the Marie seam at 1,086 feet (331 metres), near Nos. 4 and 11 pits. Flame came down this staple from the Marie seam, and traversed the short Amée incline, which was dry and dusty, to the bottom, where it was fortunately arrested. The level here was a packed road, the dust was stony, and there were two wet places. Nos. 3 and 4 samples of dust (Appendix I.) were taken as shown on the plan. Two men in the path of the explosion were killed, but all the others, 77 in number, escaped.

Eugénie Seam (Fig. 10, Plate XXIV.).—A district was worked to the north from the bowette at 1,086 feet (331 metres). It was not reached by flame. Forty-six persons were at work, of whom 31 died from after-damp. A district not working to the south from the bowette at 1,257 feet (383 metres) was not reached by the explosion. Only 4 men were at work, and they escaped.

Adelaide Seam (Fig. 10, Plate XXIV.).—At the 1,257 feet (383 metres) level, the Adelaide seam was worked to a small extent from the south bowette. The explosion did not reach this district, and 24 of the 25 workmen escaped.

The examination of Nos. 4 and 11 pits had so far resulted in clear evidence that the explosion as indicated by the direction of force had come from No. 3 pit by the Joséphine road, which [redacted]

The explosion reached No. 2 pit from the west by the Joséphine road at the 1,116 feet (340 metres) level. Two men working at the landing close to No. 2 shaft were killed by after-damp, and a boy close by, but opposite the road from the Joséphine seam, was also killed. He was said to have been burnt. From this point, the south bowette, at 1,116 feet (340 metres), offered the best route for the extension of the explosion to the south-east districts, and also to No. 10 pit. In the south bowette at 1,116 feet (340 metres), near, but to the south of, the boy last mentioned, were other boys who escaped to No. 10 pit. This bowette was arched with brickwork and limewashed: opposite to the entrance to the Joséphine seam, the brickwork was blackened with soot, but the blackening ceased a few feet to the south; and at a point, a short distance farther south, where the bowette turns east to the Ste. Barbe seam, No. 7 sample of dust was taken from the floor (Fig. 7, Plate XXI.). It is clear from the analysis, that its non-inflammable character prevented the extension of the explosion to the south-east workings of No. 2 pit, and to No. 10 pit, where some hundreds of men were at work.

The effects of the explosion in No. 2 pit will be described by taking the seams in descending order.

Julie Seam (Fig. 4, Plate XVIII.).—This seam was worked from No. 2 pit to the north by the north bowette at 1,004 feet (306 metres), which was also connected by staples near the pit with the landing and the bowette at 1,116 feet (340 metres). The ventilation was effected by a current from No. 3 pit, to which there was a communication by the north bowette at 919 feet (280 metres). The explosion did not reach the workings in the Julie seam, nor did it ascend to the 919 feet (280 metres) level at No. 3 pit. No. 8 dust sample, taken in the north bowette (Fig. 7, Plate XXI.) at 919 feet (280 metres), was of a shaly character, as shown by the analysis. Of 116 persons in this seam, all escaped except 17, 7 of whom, making light of the alarm raised and staying at their work, were killed by after-damp, and 5 men died after being removed to the surface.

It may be remarked that this Julie road was the route by which the recovery-work to No. 3 pit was conducted, the Joséphine road being impassable, at first by reason of falls, and later by the products of combustion from the fire in the José-

phine seam. Upon the occurrence of the fire and the erection of the stoppings on March 15th, the Julie route was closed, and remained so until March 27th, when the stopping in the bowette at 1,004 feet (306 metres) was opened. From No. 2 pit there was a road of communication with No. 6 pit, but as this was at the higher level of 699 feet (213 metres), it was not affected by the explosion.

Sainte Barbe Seam (Fig. 6, Plate XX.).—There was a small district near No. 2 pit communicating with the bowettes at 1,004 and 1,116 feet (306 and 340 metres) by staples, which the explosion does not appear to have traversed. Some 34 men were at work here, 12 of whom escaped.

Joséphine Seam (Fig. 7, Plate XXI.).—This seam was extensively worked across practically the whole stretch between Nos. 2 and 3 pits. The route to No. 3 pit was by self-acting inclines from the 1,116 feet (340 metres) level at No. 2 pit to the Joséphine upper levels, and thence by a recovery-drift to the Marie level and the north bowette in No. 3 pit at 1,070 feet (326 metres). There was a second route to the north end of the bowette at 1,070 feet (326 metres) by roads over the recovery-drift in the seam. The indications of force in the Joséphine seam at No. 2 pit showed that the explosion came from the direction of the workings of No. 3 pit, and that flame traversed practically the whole district with considerable violence: falls and damage being extensive,

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west Joséphine level at 1,070 feet (326 metres), near No. 3 pit; (2) by the Ste. Barbe west level at the same depth; and (3) by the west levels in the Cécile seam, near the southern end of the bowette. Higher up in No. 3 shaft, at the depth of 994 feet (303 metres), there was a communication with No. 2 pit by way of the Joséphine and Ste. Barbe seams. Still higher, at the depth of 919 feet (280 metres), by way of the north bowette at the depth of 919 feet (280 metres), there was the communication with No. 2 pit by the Julie road, so frequently referred to.

The seams worked at No. 3 pit were as follows:—Mathilde, Augustine, Cécile, Ste. Barbe, Joséphine, Marie and Adelaide.

Mathilde Seam (Fig. 4, Plate XVIII.)—There was a small district to the north reached by staples from the bowettes at 919 and 1,070 feet (280 and 326 metres). The explosion failed to reach this district by reason of the bowette at 1,070 feet (326 metres) being wet, a road to the bowette from the Joséphine seam not having inflammable dust, and the explosion not having extended to the bowette at 919 feet (280 metres). Thirty-seven men were at work, of whom 6 were saved. They made their way to the 994 feet (303 metres) landing at No. 3 pit, were found, and brought out by No. 10 pit. They were part of the group of 13 men rescued at 9·30 p.m.

Augustine Seam (Fig. 4, Plate XVIII.).—Six men were employed in a small district below the Mathilde workings, last referred to. The explosion did not reach this district for the reasons there given, but none of the men were saved.

Cécile Seam (Fig. 5, Plate XIX.).—To the south-east, a small district was being worked, employing 24 men. The explosion entered this district by way of the bowette, at 1,070 feet (326 metres): the force in the bowette coming from the north. All the men were killed.

On the west side of the bowette, at 1,070 feet (326 metres), a level to the west communicated with Nos. 4 and 11 pits. The explosion traversed this level as far as the bottom of the rise place in which the fire-stoppings in the Cécile seam were built, and about half way up the rise place. Several samples of dust were taken at Nos. 9, 10, 11, 12 and 13. Analyses are given in

Appendix I. No. 9 analysis is of dust from the floor and sides of the rise place, 16 feet below No. 7 stopping, where there was no evidence of flame or force. No. 10 analysis is of dust from a point about half-way up the rise place, and seemed to be the farthest point reached by flame. No. 11 analysis is of coked dust found in crusts on the timbers near No. 10 sample. No. 12 analysis is of dust from the floor and sides of the Cécile level at the bottom of the rise place. The level was traversed by flame to this point; but beyond it no coal was being drawn, and the character of the dust changed. No. 13 sample was taken from a point 200 feet west of the rise place, and its non-inflammable character, as shown by the analysis, accounts for the explosion being arrested and prevented from extending to Nos. 4 and 11 pits by this route.

A short distance to the south, there is another level from the same bowette in the Cécile reversed seam. The explosion did not reach this level, owing to the fact that the bowette was quite wet for 200 feet (60 metres) between the two levels.

Near the landing, at 919 feet (280 metres), of No. 3 pit, the manager, Mr. Gabriel Barrault, with 3 officials and 12 men, were at work completing the upper stoppings of the fire in the Cécile seam. They were all killed. There was distinct evidence of force having come up the pit and the staple, as shown by the destruction and projection of fixtures, tubs and other materials at the pit and at the top of the staple.

There was no evidence of flame at the 919 feet (280 metres) level or near the stoppings, but, as before stated, two of the

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From the same bowette at 1,070 feet (326 metres) and the staple, and approached also by the north bowette at 919 feet (280 metres), was a north-east district in the Ste. Barbe seam. This district was not traversed by the explosion, owing to the wet condition of the bowette at 1,070 feet (326 metres), and to there being no explosion in the bowette at 919 feet (280 metres). These two districts were connected at the top of the staple by a roadway, which, to the west, was only used for ventilation, and was not dusty. The absence of inflammable dust prevented the explosion from extending from one district to the other. From the second district, 24 men out of 58 escaped, some at 8 a.m., and others at 5·30, 7·30 and 9·30 p.m. They came out by the Julie road, but some died on the way. Three others got to the landing at 994 feet (303 metres) at No. 3 pit, whence, as part of the group of 13, they were rescued at 9·30 p.m. and taken out by No. 10 pit.

To the south-east of No. 3 pit, the Ste. Barbe seam was worked from the Cécile level at 1,070 feet (326 metres). The explosion entered by this level, and traversed part of the district. Of 49 men only 5 escaped. They, too, found their way to the landing at 994 feet (303 metres) at No. 3 pit. To the west of the south bowette, at 1,070 feet (326 metres), 22 men died by after-damp in the levels in the Ste. Barbe and Ste. Barbe reversed seams, and 2 succeeded in reaching the landing at 994 feet (303 metres) at No. 3 pit, being rescued at 9·30 p.m. The explosion was prevented from traversing the first level, in the Ste. Barbe seam, by the non-inflammable character of the dust, and the second level, in the Ste. Barbe reversed seam, by the wet place in the bowette at 1,070 feet (326 metres).

At the southern end of the south bowette at 1,070 feet (326 metres), there is an east level in the Ste. Barbe reversed seam leading to the Adelaide and Eugénie seams, from which came 8 men of the party of 13 who escaped twenty days after the explosion. It was in the *cul-de-sac* in this district (Fig. 10, Plate XXIV.) that the party spent most of the time. The explosion did not enter the district, being arrested by the wet place in the bowette at 1,070 feet (326 metres).

Joséphine Seam (Fig. 7, Plate XXI.).—This seam was worked extensively from No. 3 pit, the north-east and principal district lying between Nos. 2 and 3 pits, and adjoining the Joséphine

workings of No. 2 pit. The connections with No. 3 pit were, firstly, by the north bowette at 1,070 feet (326 metres), and the Marie level at the same depth; secondly, by the Joséphine level from the same bowette farther north; and thirdly, by an upper road from the northern part of the district to No. 3 pit by the upper bowette at 994 feet (303 metres). There was also a staple from this upper road down to the bowette at 1,070 feet (326 metres), at a point about 394 feet (120 metres) north of the Marie connection. Flame traversed nearly the whole of this district. Coke was plentiful, and there were signs of great violence. All the workmen, numbering 110, were killed.

On May 22nd, Mr. Heurteau, assistant inspector, found what appeared to be the remains of a blown-out shot-hole, 20 inches (50 centimetres) deep, and 4 inches (10 centimetres) in diameter at the mouth, at the face of the Lecœuvre heading (Fig. 7, Plate XXI.). There were also indications of force apparently outwards from this face. Much importance is attached to this place, and the question will be discussed more fully later.

To the north-west of No. 3 pit, a small district of the Joséphine seam was worked from the Marie west level at 1,070 feet (326 metres). The explosion entered by this level, and all the workmen, numbering 8, were killed.

To the west, and commencing from near No. 3 pit, south bowette, at 1,070 feet (326 metres), is the Joséphine communication with Nos. 4 and 11 pits. At numerous points along this road, evidence was observed of force from No. 3 pit to Nos. 4 and [redacted]

bowette at 919 feet (280 metres) and the No. 3 pit ventilating compartment at 758 feet (231 metres). The explosion did not reach this district, being stopped by the wet part of the south bowette at 1,070 feet (326 metres). Of 35 men at work, 5 only, including Pruvost and Nény, who remained in, were saved. They belonged to the party of 13 who escaped on March 30th. The 8 others of this party worked in the Ste. Barbe, Adelaide and Eugénie districts, on the opposite side of the south bowette at 1,070 feet (326 metres), where the explosion was also prevented from entering by the wet part of the bowette.

15.—Blown-out Shot in the Lecœuvre Heading.

Attention may now be directed to the blown-out shot in the Lecœuvre heading, and in the first place to the evidences of force pointing to that quarter as the locality of the origin of the explosion.

It has been made clear that the indications had so far been traced to the level at 1,070 feet (326 metres) in No. 3 pit. At the pit and staple, the force had been upwards from this level, and in the south bowette, at the same depth, a train of broken tubs was found thrown to the south by a force from the north. In the north bowette, near No. 3 pit, the arched girders were blown out by a force coming along the bowette from a point further north.

The indications so far described led the writers, therefore, to that part of the workings lying to the north of No. 3 pit at the level of 1,070 feet (326 metres), and in that district the indications point to the Lecœuvre heading, in which the blown-out shot-hole was found, as the point of origin (Fig. 7, Plate XXI.).

Certain evidence appeared at first to be inconsistent with that view. In the bowette to the north of the Marie junction, there were indications on a number of full tubs of force from south to north, and at the Joséphine staple down to the 1,070 feet (326 metres) level, there were indications that the explosion had gone up it; whereas the nearest route from the Lecœuvre heading would have been down the staple, and from the north in the bowette.

An examination of the roads connecting the site of the shot with the north bowette at 1,070 feet (326 metres), the roads to the top of the Joséphine staple down to 1,070 feet (326 metres), and

the Marie north-east level, afforded an explanation of these apparent discrepancies in the direction of the force; the explanation being that sections of these roads (as shewn by Nos. 16 and 17 dust samples, Appendix I.) were free from inflammable dust; and that, in consequence, the explosion had not followed the shortest routes either to the bowette or to the staple, but had gained access to both by way of the upper Joséphine road at the bottom of the Lecœuvre self-acting incline, to the east by this road and thence to the main Joséphine level at 1,070 feet (326 metres), near the recovery-drift. Here the force divided, one force continuing east to No. 2 pit and the other force going back west by the recovery-drift and the Marie north-east level at 1,070 feet (326 metres) to the north bowette at the same depth, again dividing north and south in the bowette at the Marie junction.

The north bowette, at 1,070 feet (326 metres) in No. 3 pit, was, at the time of the writers' examination, in a wet condition, and this was principally accounted for by the passage of steam from the Joséphine fire and owing to the gutters being blocked by falls. The writers were informed, however, that the bowette near the staple had been wet before the explosion—although this part of it had been traversed by flame, as evidenced by the blackened surfaces and coked dust found near the bottom of the staple (No. 20 coke sample). There was also the usual coating of dust found after explosions in dusty roads. The passage of the explosion in this part of the bowette is no doubt accounted for by the fact that the Joséphine staple was used for tipping coal [redacted]

FIG. 18.—FACE OF LECŒUVRE HEADING, SHOWING SHOT-HOLE, HEAP OF COAL, THREE BODIES AND DÉBRIS.

coal, and at the face, near the upper left-hand corner, was a shot-hole, which had the appearance of having blown out. It was 20 inches deep, shattered in its interior, and enlarged at the mouth

— Mouth of Shot-hole in Lecœuvre Heading.

of 33 feet (10 metres) from the face. On the floor at the face was a heap of about 4½ tubs of coal and slack (No. 156), and on this lay the naked bodies of three men, the brothers Lecœuvre (No. 157).

Close to the face, amongst other débris, were a pick (No. 49), a hammer (No. 51), a wedge (No. 68), an iron bar (No. 155),

FIG. 20.—CUTTING ALONGSIDE OF SHOT-HOLE IN LECŒUVRE HEADING.

drills (Nos. 55 and 67), lamps (Nos. 46 and 61), and a broken tub (No. 66). A few feet farther out were a drilling-machine (No. 47), drills (Nos. 41, 50, 53 and 54), a scraper (No. 44), double-pointed hammers or picks (Nos. 45, 56 and 115), the broken platform of a Sullivan holing-machine (Nos. 147 and 148), and a quantity of blown-out timber (Nos. 151, 152, 153, 154, etc.).

Fig. 18 shows the general appearance of the face, the shot-hole, the heap of coal, and other débris, and parts of the bodies of three men. Fig. 19 is a closer view of the mouth of the shot-

THREE BODIES AT FACE OF LECOEUVRE HEADING.

[redacted]

The heading had been ventilated by air-pipes laid on the floor at the right or lower side. These pipes were thrown out of place and much broken; the fourth pipe (No. 139), which would be probably in the line of the shot, was broken into a great number of pieces (Fig. 22).

At a distance of 62 feet (19 metres) from the face and under a fall of roof, the body of a fourth man (No. 129) was found, minus an arm (No. 128) and a leg (No. 127), which were found 10 feet (3 metres) farther outbye.

The heading was exceptionally dusty, probably owing to the use of the Sullivan machine for holing. There were plentiful indications of flame in the heading, coked dust being found in profusion on all objects and on the coal-sides of the heading near the face. The bodies of the men were deeply burned. Practically all the timber was blown out in the heading; and, up to within about 30 feet of the face, from 1 to 3 feet of the roof had fallen. No fire-damp had ever been seen in this district of the pit before the explosion, and open lights were in use. At the time of the writers' inspection, although the heading had been unventilated for nearly three months, no trace of fire-damp could be detected by the hydrogen lamp.

The explosive used was No. 1 Favier powder, and the men fired their own shots with fuse and detonator.

In this case, no missed or blown shot had been reported; and, as all the men and officials concerned were killed, it was impossible to get any direct evidence as to what had taken place during the day preceding or on the morning of the explosion.

16.—Cause of the Explosion.

After several inspections and consideration of all the circumstantial evidence, the most probable explanation that suggested itself to the writers' minds was that the shot in question had missed fire on the previous day; that at the time of the explosion the men were engaged in cutting out the shot; and that in so doing they struck the detonator and thus exploded the charge. Fig. 20 shows a recess about a foot wide to the right-hand of and above the shot-hole. This appeared to have been formed by pick-work, and might have been part of the operation of cutting out a missed shot. If the hole contained four cartridges, the detonator would

be within an inch of the front of the hole remaining in the face. The charge of this shot, consisting of from 14·1 to 17·6 ounces (400 and 500 grammes) of No. 1 Favier powder, blowing out of a short open hole into an accumulation of dry dust on the floor of a dry and dusty heading, was sufficient, the writers think, to create an inflammation of explosive violence, which, propagated by dust alone, extended throughout the mine, and produced all the terrible effects observed.

Against this explanation, it was suggested that coal-dust alone would not produce an explosion of such violence as to account for the evidences of force in the immediate locality. To this it may be replied that, in addition to the force developed by the explosion of coal-dust, there was also the force due to the explosive itself; and experiments since made with No. 1 Favier explosive and coal-dust from the Lecœuvre heading have proved that the dust can be readily ignited with explosive violence (Appendix III.).

It has also been suggested that the presence of a small percentage of fire-damp was not improbable, seeing that the heading was advancing in an unworked area of coal, and that the parallel place was being driven alongside a fault. It is impossible for the writers to assert positively that no fire-damp was present at the moment of the explosion; but it is an important fact that none had been found previously, and recent work at the face and bore-holes put forward and into the fault have failed to discover any trace of fire-damp (Fig. 7, Plate XXI.).

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the pipes after they were brought out of the pit, but the fact that the shattered pipe was in the line of the shot, and the difficulty of accounting for the presence of fire-damp in pipes on the floor where men were working with naked lights, makes it appear to the writers that the shot was the more likely cause,

FIG. 22. — BROKEN AIR-PIPES FROM LECŒUVRE HEADING.

although neither explanation perhaps accounts satisfactorily for the peculiar damage to the pipe in question.

Against the suggestion that the men were engaged in cutting out the shot, it has been pointed out that only eight tubs of coal were found at and between the face and No. 3 pit, and that this

quantity does not represent the amount of coal which would have been removed by cutting the coal away in front of the charge, and further, that the two hours, between 5 and 7 a.m., would not suffice for the work. To this objection the writers would remark that eight tubs of coal so nearly represent the quantity of coal that the cutting would involve, that along with absence of knowledge concerning the previous contour of the face the objection is not a weighty one. The work of cutting out a shot would be performed with the greatest possible despatch, as such a method of disposing of a shot was absolutely prohibited.

It is probable that the story of that unfortunate morning will never be reconstructed from ascertained facts; but, after reviewing all the available evidence and considering all the arguments, the most probable explanation appeared to be that the explosion originated in the Lecœuvre heading, and was one of coal-dust alone, that the shot in question was the immediate cause, and that it was fired inadvertently by a blow in the process of cutting out the charge which had previously missed fire.

17.—Experiments with No. 1 Favier Powder and Coal-dust.

With regard to the explosive, No. 1 Favier powder, and the possibility of ignition of coal-dust by it, there appears, from various experiments, to be no room for doubt upon the point.

Since the Courrières disaster, experiments have been made with No. 1 Favier powder and Joséphine coal-dust at the experimental gallery at Frameries, placed at the disposal of the

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of the tube were placed six frames of fir and oak, at the following distances: 14·4 feet, 35·4 feet, 53·5 feet, 59·1 feet, 64·6 feet and 70·7 feet (4·40 metres, 10·80 metres, 16·30 metres, 18·00 metres, 19·70 metres and 21·55 metres). A few of the experiments are recorded in Appendix III.

These experiments proved conclusively the dangerous character of No. 1 Favier powder when exploded in the presence of dust, under conditions such as those that existed in the Lecœuvre heading.

Some experiments, carried out in Germany in 1897, were made on a number of explosives in an artificial gallery 111·6 feet (34 metres) long, in various mixtures of fire-damp, coal-dust and air, the explosive being fired from a cannon in the usual way at one end of the gallery.* Table III. shows the result of these tests with No. 1 Favier powder in coal-dust. It is also stated that "No. 1 Favier powder ignited whirling coal-dust without any

TABLE III.—EXPERIMENTS WITH NO. 1 FAVIER POWDER AT GELSENKIRCHEN.

No. of Experiment.	Weight of Explosive used.		Coal-dust.	Fire-damp.	Temperature.				Result.
					Of the Gallery.		Of the Dust.		
	Ounces.	Grammes.			Degs. Fahr.	Degs. Cent.	Degs. Fahr.	Degs. Cent.	
1	6·7	190	Coal-dust	None	59·0	15	50·0	10	No explosion.
2	10·2	288	Coal-dust	None	41·0	5	33·8	1	No explosion.
3	13·6	386	Coal-dust	None	46·4	8	33·8	1	Explosion.
4	12·8	363	Coal-dust	None	57·2	14	37·4	3	Explosion.

admixture of fire-damp, using a charge of 12·8 ounces (363 grammes). One would, therefore, hardly call this a safe explosive for use in Westphalian coal-mines."

18.—CONCLUSIONS.

The distinguishing features of the Courrières explosion were the wide area that it covered and the great loss of life that it caused. These results were chiefly due to the fact that the workings of the several pits were connected by roads, which there are very strong reasons for believing contained no fire-damp, but

* "Weitere Versuche betreffend das Verhalten von Sprengstoffen gegenüber Schlagwettern und Kohlenstaub auf der berggewerkschaftlichen Versuchsstrecke zu Braubauerschaft bei Gelsenkirchen" (Experiments with Explosives), by Mr. F. Heise, *Glückauf*, 1897, vol. xxxiii., pages 517-523 and 544-549.

did contain inflammable dust. The recognition of this fact is of even greater importance than to know the initial cause of the explosion, because, whilst it cannot be disputed that explosions may be initiated either by explosives or by naked lights, there is still some scepticism as to whether explosions can either be initiated or propagated by coal-dust in the entire absence of fire-damp.

If the writers' conclusion, that the explosion was started by a blown-out shot of No. 1 Favier explosive, is correct, it should emphasize the fact that all explosives used in coal-mines are capable of igniting gas or coal-dust. If, on the other hand, the explosion was initiated by fire-damp, it shows the great danger of using naked lights in any dusty coal-mine.

Whether the Courrières explosion was initiated by a blown-out shot or by a local explosion of fire-damp, does not, in the writers' view, interfere with the main conclusion that it was through the agency of coal-dust that the explosion was carried throughout the mine. The fact of supreme importance remains, namely, that, however originated, an explosion may traverse the whole extent of the largest mines by means of coal-dust alone. The writers have no doubt that this was the case at Courrières.

The prevention of such wide-spreading dust explosions is a subject requiring the most serious attention of those concerned in the management of collieries. It opens a wide field for experiment and discussion, as to the most efficient and practicable [redacted]

maintained in such repair that the small coal will not be scattered in transit. In some cases dangerous dust is carried into the pit from the screens at the surface by the intake-air. To prevent the production of dust in dry mines is, perhaps, impossible, but it is neither impossible nor impracticable very greatly to reduce the danger; and, until efficient measures to that end are more generally adopted, the writers cannot feel that mining engineers have done what is necessary to combat one of the greatest elements of danger with which they have to contend.

Although the plan of connecting the workings of a large number of pits is not generally practised in Great Britain, and the loss of life in any one explosion has never reached the terrible figures seen at the Courrières collieries, there are not a few large collieries where the workings extend for several miles, and the various seams are more or less connected by roads available for the passage of a dust explosion. In such collieries upwards of one thousand persons are not infrequently employed at one time, so that the circumstances connected with the Courrières explosion and the lessons to be learnt need to be carefully considered. In such extensive and dusty collieries effectual means should be taken to guard against the dangers so painfully forced upon the writers' notice by this lamentable catastrophe. The destruction of the No. 3 shaft, which so seriously interfered with the rescue-work, proves the liability of bratticed shafts to be blocked by an explosion.

The loss of life at Courrières was as follows: Killed underground, 1,089; brought out alive, but subsequently died, 7; rescuers killed underground, 3; killed on the surface, 1; a total of 1,100 persons. In addition, 98 horses were killed.

19.—Recovery of Bodies.

The recovery of the bodies was naturally a difficult and protracted task. Excellent sanitary precautions were taken, as set out in Appendix IV. Sickness has not been reported amongst the persons employed in the recovery-work. The bodies were disinfected where found, and were coffined and sent to bank as soon as the roadways were passable. Identification was possible in the majority of cases, even to the last. Some of the bodies

presented a mummified appearance; but generally, and particularly in wet places, they were in various stages of advanced decomposition.

On arriving at the surface, they were examined by doctors, who were always in attendance, for signs of burning, asphyxiation, or other special features. The doctors stated that, so far as could be ascertained, none of the dead survived the day of the catastrophe.

The bodies were recovered as follows:—During March, 189; April, 306; May, 271; June, 210; and July, 91. Further bodies were recovered up to August 24th; and on November 10th, 1906, 13 bodies had not been found, namely: 2 lost in Nos. 4 and 11 pits; 2 burnt in the first fire in the Joséphine seam at No. 2 pit; and 9 enclosed within the stoppings of the second fire in the Joséphine seam at No. 3 pit.

The writers cannot conclude their paper without expressing their great obligations to the State authorities and engineers, and to the engineers and managers of the Courrières Coal Company, for their great assistance rendered in the investigations, and their readiness in furnishing information and material for this paper.

The writers trust that their work has added at least some contribution of value to the knowledge of the causes of colliery explosions, and particularly that attention may be directed to the question of coal-dust, so as to result in some diminution of

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APPENDIX I.—ANALYSES OF DUST, ETC.—*Continued.*

No. of Sample.	No. of Pit.	Description of Dust.	Observations.	Composition of Dust. Fixed Carbon.	Volatile Matter.	Ash.
				Per cent.	Per cent.	Per cent.
2	4 and 11	Dust from the floor and sides of the Joséphine west level, at 981 feet (299 metres); air and travelling road to Nos. 5 and 12 pits.*	No explosion	42·60	25·00	32·40
3	4 and 11	Dust from the Amée south-west level below the staple from the Marie seam, at 1,086 feet (331 metres).†	Explosion arrested	26·50	14·85	58·65
4	4 and 11	Dust from the same Amée level, but near the top of the staple to the Adelaide seam, at 1,257 feet (383 metres).†	Explosion arrested	29·00	19·20	51·80
5	4 and 11	Dust from between the flanges of the vertical side of a girder-arch, adhering by the force of its projection, in the south bowette, at 981 feet (299 metres), near Nos. 4 and 11 pits.*	No explosion	31·30	21·70	47·00
6	4 and 11	Dust from the floor of the bowette, at 981 feet (299 metres), near the girder last referred to.*	No explosion	36·00	25·90	38·10
7	2 ...	South bowette, at 1,116 feet (340 metres), about 230 feet (70 metres) from No. 2 pit, and main road communicating with No. 10 pit.*	No explosion	25·75	19·65	54·60
8	3 ...	North bowette, at 919 feet (280 metres), and about 1,312 feet (400 metres) north of No. 3 pit.	No explosion	38·45	25·55	36·00
9	3 ...	Dust from the floor of a rise place in the south-west Cécile seam, at 1,070 feet (326 metres), and 16 feet (5 metres) below No. 7 stopping.‡	No explosion	39·40	22·85	37·75
10	3 ...	Dust from the floor of the same rise place, near the farthest point reached by the flame.‡	Explosion ...	44·58	27·42	28·00
11	3 ...	Crust of coked dust deposited on the timber, about halfway up the rise place to No. 7 stopping.‡	Coke resulting from explosion	56·65	18·10	25·25

* Fig. 7, Plate XXI. † Fig. 9, Plate XXIII. ‡ Fig. 5, Plate XIX.

APPENDIX I.—ANALYSES OF DUST, ETC.—*Continued.*

No. of Sample.	No. of Pit.	Description of Dust.	Observations.	Composition of Dust.		
				Fixed. Carbon.	Volatile Matter.	Ash.
				Per cent.	Per cent.	Per cent.
12	3 ...	Dust from the floor of the Cécile level, at 1,070 feet (326 metres), at the bottom of the rise place referred to in Nos. 9, 10 and 11 analyses.‡	Explosion .	45·76	27·37	26·87
13	3 ...	Dust from the Cécile level, at 1,070 feet (326 metres), same as above, but 230 feet (70 metres) farther west.‡	Explosion arrested	24·90	15·20	59·90
14	3 ...	Joséphine north-east level, at 1,070 feet (326 metres): sample of coal from the interior of the shot-hole at the face of the Lecœuvre heading.*	—	65·50	29·35	5·15
15	3 ...	Joséphine north-east level, at 1,070 feet (326 metres): dust from the floor of the Lecœuvre heading, near the face.*	Explosion ...	67·15	24·00	8·85
16	3 ...	Dust from the Joséphine main north level, at 1,070 feet (326 metres), leading from the bowette at the same depth to the Lecœuvre heading.*	Explosion arrested	35·45	22·25	42·30
17	3 ...	Dust from the Joséphine air-way to the top of the Joséphine staple	Explosion arrested	19·60	15·45	64·95

[redacted]

ash, determining the non-combustible ingredients or inert matter, are of special significance and interest.

Samples of dust for analysis should be collected with care, and all the circumstances present considered and noted. The results of the analyses may frequently be perplexing, if not misleading, because of (1) the difficulty of obtaining, in small quantities, an average sample of the dust of a given length of roadway; (2) the possibility that the deposit after the explosion differs from that existing before the explosion by reason of (*a*) the removal of the original dust by the force of the blast, (*b*) the deposit of new dust brought from another place by the blast, and (*c*) the chemical change resulting from the combustion more or less of the dust during the passage of flame. Samples of dust, taken from roads beyond the limit of flame, may give reliable figures to guide one in considering the quality of a non-inflammable dust; but other factors must be taken into account, namely: dryness, quantity, probably the size of the road, the intensity of the explosion and the flame arriving at the place, its velocity, and the character of the dust-cloud carried by it.

Samples of dust taken from a road after the passage of flame may be much altered in character in varying degrees, according to the intensity and duration of the combustion during the passage of the explosive flame. The results of the analyses would, in the case of partially-burnt dust, show low percentages of carbon and volatile matter with a correspondingly high percentage of ash. The examination of such dust, after explosion, under a microscope will generally reveal globular or shelly particles of fused coke.

APPENDIX II.—Explanation of Fig. 11, Plate XXV.

1.—Timber thrown out-bye, with a piece of air-pipe embedded at one end. The small sketch shows a plan and elevation of this object.
2.—Sleeve of a shirt.
3.—Piece of cloth.
4.—Compressed-air pipe.
5.—Piece of air-pipe.
6.—Clothing.
7.—Piece of air-pipe.
8.—Two pieces of board from a door.
9.—Fuse and clothing.
10.—Piece of fuse: burnt?
11.—Cord: door-cord?
12.—Small bottle: broken.
13.—Clothing.
14.—Tub on its wheels, under a fall.
15.—Board and iron of tub: the wheels are at No. 31.
16.—Broken piece of timber, with a piece of air-pipe embedded in it.
17.—Piece of board.
18.—Board, part of tub, No. 15.
19.—Sock.
20.—Hinge.
21.—Box of tools.
22.—Board.
23.—Five machine-picks, and a bundle of tallies, No. 23.
24.—Piece of iron from a tub.
25.—Piece of fuse: burnt?
26.—Lamp, No. 442: Henri Lecœuvre.
27.—Fragments of clothing.
28.—End of fuse, 20 inches or 0·50 metre long: burnt?
29.—Iron drag.
30.—Iron drag.
31.—Wheels, part of tub, No. 15.
32.—Piece of leather-belt.
33.—Iron bar, No. 347.
34.—Iron bar, No. 351.
35.—Piece of air-pipe.
36.—Piece of fuse: burnt?
37.—Tally, No. 165.
38.—Two pieces of iron from a tub.
39.—Bundle of tallies, No. 146, and pieces of cloth.
40.—Leather hatband.

41.—Drill.
42.—Piece of leather hatband.
43.—Iron bar, No. 317.
44.—Scraper.
45.—Pick.
46.—Lamp, No. 548.
47.—Drilling-machine.
48.—Rammer, with the big end towards the face.
49.—Pick.
50.—Drill.
51.—Hammer.
52.—Plank.
53.—Drill.
54.—Two drills.
55.—Twisted drill, head covered with pieces of cloth.
56.—Pick.
57.—Piece of fuse, 20 inches or 0·50 metre long: burnt.
58.—Shoe.
59.—Leather hat.
60.—Leather loop, for carrying a lamp in the hat.
61.—Lamp No. 443: Joseph Lecœuvre.
62.—Two feet of a trestle.
63.—Numerous fragments of clothing, between the side of the tub and the side of the heading.
64.—Shovel, with the pan in the coal and the handle under the tub.
65.—Two ends of leather-belts, 4 inches or 0·10 metre each in length, [redacted]

81.—Powder-box.
82.—Knitted vest.
83.—Sock.
84.—Waistcoat.
85.—Shirt.
86.—Shirt.
87.—Vest.
88.—Piece of air-pipe.
89.—Piece of air-pipe.
90.—Piece of air-pipe.
91.—Piece of air-pipe.
92.—Piece of air-pipe.
93.—Piece of air-pipe.
94.—Piece of air-pipe.
95.—Piece of air-pipe.
96.—Pieces of timber, apparently belonging to a trestle.
97.—Piece of air-pipe.
98.—Timber.
99.—Air-pipe.
100.—Air-pipe.
101.—Air-pipe.
102.—Air-pipe.
103.—Air-pipe.
104.—Air-pipe.
105.—Air-pipe.
106.—Air-pipe.
107.—Air-pipe.
108.—Air-pipe.
109.—Air-pipe.
110.—Air-pipe.
111.—Air-pipe.
112.—Air-pipe.
[redacted]

131.—Five pieces of square trestle-timber.
132.—Three pieces of square trestle-timber?
133.—Mouldiness on the side of the heading.
134.—Piece of cloth.
135.—Fallen timber, with a piece of air-pipe embedded in it, on the side towards the face.
136.—Square timber.
137.—Piece of leather-belt.
138.—Fuse, 20 inches or 0·50 metre long, burnt? and pieces of cloth.
139.—Fourth air-pipe (Fig. 22), broken into small pieces, and found scattered over 33 feet or 10 metres out-bye.
140.—Collar of air-pipe No. 139 was found in air-pipe, No. 118.
141.—End of air-pipe.
142.—Pieces of timber and pieces of air-pipe under a fall.
143.—Tramway intact out-bye from this point.
144.—Piece of a hat.
145.—Pieces of cloth.
146.—Square trestle-timber?
147.—Platform of drilling-machine.
148.—Plank from platform of drilling-machine.
149.—Trestle of drilling-machine.
150.—Piece of fuse, 6 inches or 0·15 metre long.
151.—Square timber.
152.—Timber, 3 feet 7 inches by 6 inches by 5 inches or 1·10 metres by 0·15 metre by 0·12 metre.
153.—Timber, 2 feet 5 inches by 5 inches by 4 inches or 0·75 metre by 0·12 metre by 0·11 metre.
154.—Timber, 2 feet 7 inches by 4 inches by 4 inches or 0·80 metre by 0·11 metre by 0·10 metre.
155.—Iron bar, No. 360.
156.—There were 4½ tubs of coal lying at the face: No. 66 tub was nearly full.
157.—Bodies of three men: the brothers Lecœuvre.
158.—Oil-can.

APPENDIX III.—EXPERIMENTS WITH No. 1 FAVIER POWDER AND COAL-DUST.

No. 1 Experiment.—Charge, 14·1 ounces (400 grammes) of No. 1 Favier powder without dust or fire-damp. Flame was observed as far as the second window, or 7 feet (2 metres) from the cannon. Mechanical effect, slight.

No. 3 Experiment.—Charge, 7·0 ounces (200 grammes) of No. 1 Favier powder and 13·2 pounds (6 kilogrammes) of dust, put into suspension by the first fan. No flame observed.

No. 4 Experiment.—Charge, 10·6 ounces (300 grammes) of No. 1 Favier powder and 13·2 pounds (6 kilogrammes) of dust. No flame observed.

No. 5 Experiment.—No. 3 experiment was repeated. Flame observed for 66 feet (20 metres). The first frame was disturbed. Coke or charred dust began at 2 feet (0·60 metre) and extended as far as 39 feet (12 metres).

No. 7 Experiment.—Charge, 14·1 ounces (400 grammes) of No. 1 Favier powder. The dust of a preceding experiment was left in the tube, and a new quantity of 13·2 pounds (6 kilogrammes) was put into suspension by each fan. The flame leapt out of the tube for a distance of 7 feet (2 metres) and retired. There seemed to be two successive flames from Nos. 13, 14, 15 and 16 windows. The first and fourth frames were displaced. Coke was deposited as far as 59 feet (18 metres), and was found on both sides of the frames.

No. 8 Experiment.—Charge, 14·1 ounces (400 grammes) of No. 1 Favier powder. The dust (13·2 pounds or 6 kilogrammes) was put into suspension by the second fan, which was afterwards stopped. Dust (6·6 pounds or 3 kilogrammes) was spread by a hand-sieve for a length of 30 feet (9 metres),

and 6·6 pounds (3 kilogrammes) was put into motion by the first fan. Flame shot out of the gallery, for a length of 23 feet (7 metres), and coke was deposited on the whole length of the gallery. The frames were intact, but the sixth frame was burnt.

No. 19 Experiment.—Charge, 17·6 ounces (500 grammes) of No. 1 Favier powder. Dust (6·6 pounds or 3 kilogrammes) was distributed over the last 30 feet (9 metres) and 6·6 pounds (3 kilogrammes) was thrown into suspension by each fan. A ventilating pipe from Courrières colliery was wedged obliquely against the top part of the gallery, its centre being 23 feet (7 metres) from the cannon. A wooden tub from Courrières colliery was placed in the gallery at 21 feet (6·50 metres) from the entrance. A disc of paper closed the end of the tube. Flame shot out of the gallery to a length of more than 49 feet (15 metres), and set the grass on fire on the slopes. The tub was projected outside for a distance of 13 feet (4 metres), and partly destroyed. A clot of liquid tar was observed 16 or 20 feet (5 or 6 metres) from the end of the gallery. Coke was deposited over the whole length, but it was less abundant than in some previous experiments, less sticky, and more spongy. It was deposited on the sides of the frames facing the cannon. The frames were intact, except the first and third. The pipe had fallen, and was slightly damaged at the end.

APPENDIX IV.—Instructions as to the Sanitary Precautions to be taken by the Workmen engaged in Recovering the Bodies.

1.—All workmen employed at the Nos. 2 and 4 pits shall, before descending, bathe themselves about the face, neck and hands with a solution of quassia amara. For this purpose, the engineers will have two vessels containing this solution at the pit-top. It will be prepared by the storekeeper by extracting 17·6 ounces (500 grammes) of quassia-chips in a bucket of water. After the men have descended, the storekeeper will return the pails to the store, after having emptied their contents.

2.—The explorers engaged in the gases, the coffin-bearers, and generally all those who are exposed in the neighbourhood of bodies, shall move

with a layer of calmette mixture, consisting of 80 parts of powdered coal, 10 parts of sulphate of iron and 10 parts of chloride of lime. An ample supply of this mixture will be kept in the pit.

6.—The same precautions as for bodies must be taken for portions of bodies, if any, found under falls. They will, of course, be coffined.

7.—Until the arrival of the Draeger apparatus, the workmen placing bodies in coffins will wear Poteau masks and indiarubber-gloves. Their clothing must not be loose.

8.—(*a*) On returning to the surface, the gloves must be soaked for 5 minutes in a 1 per cent. solution of permanganate of potash. This will colour them red, and they must then be soaked in a 2 per cent. solution of bisulphite of soda, until the red colour disappears. They must then be rinsed in clean water. (*b*) Wool and flannel clothing, vests, shirts, etc., and boots are disinfected by formol: these last after brushing with sublimate powder. (*c*) All other clothing will be disinfected by stoving under pressure.

9.—Dead horses must be well sprinkled with cresol, and afterwards covered with calmette mixture. Workmen engaged in the pits and roads, which have been flooded, should bathe their hands, feet and face in a solution of sublimate before washing.

René Petitjean.
Engineer directing the work of rescue.

Seen and approved,
Dr. Sourties.

APPENDIX V.—Commission of Inquiry.*

The escape of survivors from the mine 20 and 25 days after the explosion, and reports circulated to the effect that others, who might have been rescued, had lived for some time, created a great sensation, and led to accusations of lack of skill and courage on the part of those directing the operations.

This gave rise to the appointment by the State of a Commission of Inquiry, consisting of Mr. Adolphe Carnot, inspector-general of mines; Messrs. Louis Aguillon and Edmond Nivoit, inspector-generals of mines; Messrs. Cordier and Bernard Évrard, delegate-miners; and Mr. H. Kuss, chief inspector, as secretary. The Commission discussed in their report: (1) The principle of the intervention of the State inspectors in the operations. (2) The abandonment of measures to remove the obstruction in No. 3 pit, and the reversal of the ventilating current. (3) Whether the State inspectors were to blame in not consulting the representatives of the miners, and notably the delegate-miners. (4) The erection of the stoppings after the discovery of the Joséphine fire at No. 2 pit, and particularly the stopping in the bowette at 1,004 feet (306 metres) leading to the Julie Seam. (5) The resumption after March 30th of the explorations which had been abandoned on March 11th. (6) The question of workmen who may have perished in the mine since the catastrophe.

* "Rapport de la Commission chargée par M. le Ministre des Travaux Publics, des Postes et des Télégraphes de procéder à une enquête sur les conditions dans lesquelles ont été effectués par les ingénieurs de l'État les Travaux de Sauvetage à la suite de la catastrophe survenue aux mines de Courrières le 10 mars 1906," *Journal Officiel*, August 11th, 1906.

As these are questions which must have occurred to many who have followed the published accounts of the disaster, the writers give the gist of the arguments and conclusions of the Commission.

The Commission failed to agree in their conclusions, and Messrs. Cordier and Évrard, delegate-miners, sent in a minority report which was published in the newspapers. The Minister of Public Works then instructed the Commission to re-open the inquiry. In their final report, Messrs. Cordier and Évrard still hold views opposed to those of the majority.

The points coming under inquiry were discussed as follows:—

1.—The French law by a decree of January 3rd, 1813, articles 14 and 17, requires the authorities to intervene when a fatality occurs and the bodies are not recovered, or when there is a probability of survivors. The execution of the work is to be under the direction of the State engineer, or, in his absence, of experts, appointed by the authorities. The owners and engineers of neighbouring mines are required to furnish in men and materials any assistance which may be required. It was, therefore, to conform to the law that the State inspectors assumed authority and control.

2.—Messrs. Cordier and Évrard, the minority, held Mr. A. Bar, the Courrières Coal Company's technical director, to blame, for not adopting the proposal to clear the obstruction in No. 3 pit by dynamite, or otherwise, and they charge him with having been guilty of an inexcusable fault. The majority of the Commission confirmed the action of Mr. Bar in his decision, which was taken after consulting with the authorities. Messrs. Cordier and Évrard condemned the reversing of the ventilation, declaring that it jeopardized the safety of any one still in the mine. The majority held, on the contrary, that No. 3 pit being blocked, the reversal of air was necessary and justifiable for the safety of the rescuers. Had survivors been suspected, they could not have been reached before the main roads had been cleared of bad air. On the question of the independent ventilation of Nos. 4 and 11 pits, which would have permitted rescue-work to proceed at these pits, the majority commend the prudence of Mr. O. Delafond, who believed that it would have been impossible to isolate that current from the fire in the Cécile seam, which threatened the rescuers with an unknown danger. The Commission

[redacted]

necessary as was at the time believed, it was not possible to form any other opinion on March 17th. In any case, the stopping, at 1,004 feet (306 metres), was reopened 24 hours before the survivors of March 30th attempted to come out. They stated that the whole operation of dealing with the Joséphine fire commended itself to them.

5.—Messrs. Cordier and Évrard asked whether the descents at Nos. 4 and 11 pits of April 3rd and 4th were not undertaken with a view to restore the pits rather than to search for survivors. The majority replied that it was ridiculous to suppose that the numerous officials who conducted those searches, including State engineers and workmen's delegates, would have undertaken an exploration full of danger for such a purpose, and that although Berthon came out on April 5th, it could not be expected that every corner of the pit could have been searched by that date, seeing that the full exploration was not completed before April 30th, owing to the great damage found in the roads and the presence of a poisonous atmosphere.

6.—Upon the question as to whether any workmen had perished in the mine after the catastrophe, and, if so, whether the death of those workmen was any reproach to the engineers who had charge of the rescue-work, Messrs. Cordier and Évrard did not hesitate to reply in the affirmative to these questions, and they made the following statement:—

"On March 31st, the gang Blaise, Simon and Pélabon found at the landing, at 994 feet (303 metres), in No. 3 pit, 4 bodies where there had only been one on March 10th. C. Surmont, an employee of the company, a sub-inspector of No. 2 pit, had made a further deposition. He had declared before the Commission that he had seen, after the escape of the 13 men, in the Julie level, 11 bodies, which were not there on March 10."

"On April 4th, in No. 4 pit, at 1,086 feet (331 metres), we, Messrs. Cordier and Évrard, made an exploration of the landing, proceeding by the south bowette to the Joséphine, Ste. Barbe (in part) and Cécile seams. We found there bodies of miners naked to the waist and evidently surprised whilst at work, but further in the Ste. Barbe and Cécile seams we encountered bodies of workmen who were clothed. In the Cécile seam we ascertained that certain of the air-pipes had been blocked, one with clothing placed on the face of it, and another with a block of coal. There we found food-boxes, bottles, a box of eggs (opened), and all empty of their contents. These are evident proofs that men had survived, had expected to be saved, and had attempted, whilst waiting rescue, to keep away the bad air which was coming to them."

"The discovery of new bodies, after the resumption of rescue-work, which were not there on March 10th and 11th, the 13 who escaped, the situation of the dead discovered by ourselves and their attempts at self-preservation, all prove absolutely that these unhappy men had wandered in the workings of the mine without being discovered, from March 10th, the day of the catastrophe, up to April 4th."

To this statement, the majority of the Commission replied that the observations made by Messrs. Cordier and Évrard in the visit which they thought it advisable to make privately to the No. 11 pit on April 4th were badly interpreted by them, and a little more circumspection would have shown them an error of vital importance. The district which they visited was occupied on March 10th by 8 workmen:—That is to say, in the Cécile No. 2 branch, at 1,086 feet (331 metres), to the east of the recovery-drift (Sevin and Châtelain), ventilated by air-pipes from the recovery-drift; in the face of the recovery-drift (Laurent and Lefèvre), ventilated by a pipe

passing through the door in the Ste. Barbe road; and in the Ste. Barbe second branch (Delplanque, Danel, Broy and Lucas), ventilated by a pipe of which one branch went to one face and the principal branch to the other. Two of these 8 workmen (Delplanque and Broy) were saved on March 10th in the evening, as recounted by Mr. Domézon in his deposition to the Commission on April 2nd. The depositions signed by Delplanque and Broy received by the State engineers on March 17th and 19th were formal. It was they and their comrades who stopped the pipe to keep back the fumes which invaded their places. Three of them made a first attempt to escape by the recovery-drift, one of these perished in this attempt and the second, Broy, nearly met the same fate. At 8·30 p.m., the 7 survivors, sensible of the bad air invading the face where they were taking refuge, resolved to attempt to escape, cost what it might. Three fell in the Ste. Barbe road, the second branch where their bodies had been found, and 2 in the recovery-drift, Broy and Delplanque alone escaping to the pit. They had since declared that they did not hear any calls from any other survivors. Imprisoned in their place, from 5 a.m. until 8·30 p.m., it is not astonishing that these 8 workmen sustained themselves on the provisions in their food-boxes, in their bottles, and the eggs that one or other of them had carried for his morning repast.

Concerning No. 3 pit, two facts were advanced. According to Messrs. Cordier and Évrard, Surmont, an employee of the company, had declared before the Commission that he saw 11 dead in the Julie gallery, which were not there on March 10th. Although the deposition of Surmont was immediately afterwards rectified by that of the vérificateur Blaise, it did not figure, with such precision, in the notes taken by the secretary and embodied by him in the *verbatim* report. The Commission made further inquiries. Delegate-miner Simon, in his explorations of March 10th and 11th, and Mr. Leprince-Ringuet on March 11th, had seen and noted 8 bodies in the Julie main level, at 919 feet (280 metres), and 3 bodies in the bowette at the entrance of the Julie level, making a total of 11 bodies, of which 7 had been recognized and 4 were unknown. Delegate-miner Simon had formally declared that he did not see on March 30th any other bodies

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two legs. No. 245 body had the face protected by a woollen scarf partly burnt, the parts of the face not protected showing extensive burns, the breast presented numerous burns, also the belly and the two legs. The doctors' report concluded as follows:—"We conclude that these 4 workmen had been at first burnt, but that death was caused by poisoning by carbon monoxide, and the burns not presenting any signs of healing indicated that their decease was not later than March 10th."

The majority of the Commission conclude their discussion of this point as follows:—In the presence of these formal declarations, we are compelled either to admit simply, that these 4 unfortunate men were on March 10th at the point where they were found on March 30th, and that by some circumstance they were not seen, or that at any rate they had not long survived their burns and the poisonous gases which followed the explosion, and came to die at the landing of No. 3 pit shortly after the exploration of March 11th, as they had died in all other parts of the mine. Sad as is this statement, one must remember that there are few great explosions where the victims of asphyxiation after the explosion are not more numerous than those of the explosion proper. It is a general and well-known fact, and is proved at Courrières as elsewhere. The proof is found in the recital of the survivors: Broy and Delplanque, of whom we have spoken, belonged to a gang of 8 workmen, 6 of whom were asphyxiated more than 12 hours after the explosion. The 13 survivors of March 30th belonged to gangs, one of which lost 5 men who went to sleep the first day under the action of the carbon dioxide and never awakened, and the other gang lost 3 men on the second or third day, as shown in the deposition of the survivors. Berthon, the survivor who came out on April 4, was one of a numerous gang who fell victims all along the road in trying to save themselves. In a general way, although many workmen had been attacked directly by the flames, it was certain that many others had been poisoned by carbon monoxide or asphyxiated by carbon dioxide, some in their working-places, which were invaded by the bad air, and others during their attempts to escape. What we can say is that the workmen, who had thus succumbed, found death in sleep without enduring the suffering which they would have had to undergo if they had been imprisoned in a confined place, where they would have been tortured by hunger or by the gradual rarefaction of the respirable air.

In the final report, the majority of the Commission, Messrs. Carnot, Aguillon, Nivoit and Kuss, arrived at the following conclusions:—

1.—The intervention of the State engineers was in conformity with the laws regulating mines. Responsibility therefore cannot be placed upon any agent of the company for any steps taken while the State engineers were in charge. The delegate-miners had no legal claim to be heard: they might have presented their observations in their reports, but they did not avail themselves of this facility.

2.—There was no evidence that any miners, who had survived the explosion, and who might have been rescued had died in the mine. Post-mortem examinations had demonstrated that those who were stated to have died a long time after the explosion were burnt and asphyxiated at the beginning. The evidences found in the pit, which seemed to suggest that men had lived, were caused by those who escaped, or by those who died on the first day. The 8 miners, who were with the 13 who escaped, were asphyxiated, 5 on the first day and 3 on the second or third day.

3.—The rescue-operations were particularly difficult, owing to the extent and destruction of the workings. The programme and measures adopted were in accordance with the practice of good mining, and as required by the circumstances. The removal of the obstruction in No. 3 pit by violent means was not feasible, and presented risks of grave consequence. No. 3 pit not being acessible, the reversal of the air-current was justified by apprehension of danger from the Cécile fire. It helped to clear the pit of irrespirable gases which had prevented the earlier escape of the 13 survivors. The establishment of the stoppings in the Joséphine and Julie roads was necessitated by the fire which broke out after the explosion. This fire created a situation extremely perilous for the rescuers, and called for measures of prudence and caution to prevent a new catastrophe. The stoppings during the time that they were closed did not constitute a danger to any survivor.

4.—In consequence, the majority of the Commission hold that it was not possible to reproach those responsible for the organization and carrying out of the operations of rescue.

THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
DECEMBER 10TH, 1906.

MR. JOHN NEWTON, PRESIDENT, IN THE CHAIR.

The minutes of the Annual General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—

Mr. C. A. ATKINSON, Stafford Coal and Iron Company, Limited, Stoke-upon-Trent.
Mr. C. H. CLARK, Estate Office, Newton-le-Willows.
Mr. C. V. GOULD, West View, Oakhill, Stoke-upon-Trent.
Mr. JOHN NIXON, Baddesley Colliery, Atherstone.
Mr. WILLIAM SIMONS, Basford, Stoke-upon-Trent.
Mr. E. P. TURNER, Longton.

ASSOCIATE MEMBERS—

Mr. B. C. BROUGH, Stafford.
Mr. F. HARRIS, Providence Foundry, Burslem.

ASSOCIATES—

Mr. L. CLIVE, Chell Lodge, Burslem.
Mr. C. NEWTON, 163, Tyldesley Road, Atherton, Manchester.
Mr. J. P. WINSTANLEY, Whitfield Colliery, Tunstall.

STUDENT—

Mr. M. GARDNER, Stafford Coal and Iron Company, Limited, Stoke-upon-Trent.

Mr. JOHN BENTLEY read the following paper on "Improved Constructions of Rails and Rail-joints for Collieries, Mines and Quarries":—

IMPROVED CONSTRUCTIONS OF RAILS AND RAIL-JOINTS FOR COLLIERIES, MINES AND QUARRIES.

By JOHN BENTLEY.

In these days of excessive competition, lessened hours of labour and increased wages in coal- and ironstone-mines, it has become absolutely necessary to look about for possible reductions of working costs, and avoidance of waste in materials; and, whether the individual savings be large or small, the aggregate amount will most likely total up to so much as to make the difference, in many mining ventures, between a loss and a moderate profit. With such an idea in view, the writer had for a considerable time paid close attention to the construction of underground railways, and now he is pleased to have an opportunity of laying before the members a description of improved rails and rail-joints, which are likely to be advantageous both as regards efficiency and as regards economy wherever they are adopted.

When laying an underground tramroad or railway, it is exceedingly difficult, in the semi-darkness of the mine, with an ordinary bridge-rail laid on a sleeper with a butt-joint, to secure its proper alignment, and considerable care must be [redacted]

I.—In this design, a piece of the arch or top of one end of a bridge-rail is cut out, so as to form a groove or gap (about 1 inch long and ½ inch wide), vertically downward through the arched portion of the bridge (Fig. 1, Plate XXVI.). The opposite end of the rail has a projection formed by cutting away a portion of the end and side-flanges and welding or squeezing together, by suitable means, the remaining portion of the end so as to form a projection (Fig. 2, Plate XXVI.). When laid in position, the projection or tongue of one rail fits into the groove of the adjacent rail, thus forming a smooth and almost rigid joint. A great advantage is that one nail in each rail will suffice, instead of the two required in the ordinary method, each rail receiving the benefit of the nail in the adjacent rail. A further point to be considered is the preservation of the sleepers; for, by this method, they may be used several times, whilst under the ordinary system it seldom happens that a sleeper, which has had four nails driven into each of its ends and taken out, is of any use for relaying.

II.—The bridge-rails used in this design are of the ordinary description, but nail-holes are not required at either end. The rail is fixed in a chair or clip constructed of steel-plate, cast-steel or malleable-iron, having a longitudinal raised central portion of a proper size to fit into the under part of the end of a bridge-rail and the end of an adjacent rail in alignment (Fig. 3, Plate XXVI.). The chair or clip has an edge turned up on each side parallel to the longitudinal raised portion, so as to prevent any possibility of the rails lifting off the chair or clip (Fig. 4, Plate XXVI.). These chairs or clips (Fig. 5, Plate XXVI.) are secured to the sleepers by nails or bolts; and, when laid in position, the rails slide into the chair, and nailing is not required. This method has a special advantage in having the chairs or clips fitted to the sleepers, to the proper gauge, before they are taken into the mine; whereas, in the ordinary method of laying rails, it sometimes happens that the miner lays his rails either too wide or too narrow for the gauge of the wheels of the tubs, and so contributes very largely to the trouble of tubs getting off the road, thus causing delay in colliery-locomotion. A further advantage will be derived from economy in sleepers, as they will last longer, not being subject to the destruction caused by careless removal of the rails from the sleepers by means of a pick in the ordinary way.

III.—The design of the third method is essentially the same in principle as that last described. The central raised portion and the turned-up edge correspond with similar features in the second system above-mentioned, the only difference being that, instead of the lugs or projection, with holes for nailing or bolting the chair on the top of the sleeper (Fig. 3), both ends of the chair are turned downward, Figs. 6, 7 and 8 (Plate XXVI.), forming a clip on two sides of the sleeper, so that it may be nailed at the sides instead of on the top of the sleeper. It will be noticed that two nail-holes are shewn (Fig. 7), but in actual practice one nail placed in the middle on each side is quite sufficient to keep the chair or clip firmly in position. It is almost needless to repeat, that the advantages claimed for the methods previously described apply equally to this particular form of chair or clip.

IV.—The fourth method is particularly well adapted for use in longwall and drift-work, or similar places where the rails and sleepers are required to be removed and relaid at frequent intervals. This form may be better described as a plate, rather than as a chair. It consists of a plate, with a raised central portion, fitting into the under part of a bridge-rail, with a nail-hole on each side of the plate for fastening it on the sleeper (Figs. 9, 10 and 11, Plate XXVI.). As in the two previously-described chairs, the plates are attached to the sleepers, to the proper gauge, before they are sent into the mine. The advantage

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is passed through the rail and clip or plate, thus forming a firm joint which will not allow the rails to slip on a steep incline, such as a jig or engine-dip.

In conclusion, a few of the advantages to be obtained by the adoption of the proposed improvements in rails and rail-joints for collieries, mines and quarries, may be summarized as follows:—

(1) Simplicity in construction is a great feature in the case of these rails and joints. (2) Economy in materials, such as sleepers, nails, etc., as well as in cost of labour in repairing roads. (3) Dislocation of underground traffic is avoided or lessened. (4) Derailment of tubs and trams is likely to be reduced to a minimum. This has been proved by severe tests on underground roads, where cases of tubs getting off the rails are now almost unknown. (5) Accidents are lessened in number, where caused by props being knocked out by derailed tubs or trams. And (6) saving of labour in laying and relaying temporary roadways, such as are required in longwall or drift-work.

Mr. W. G. Peasegood asked what length of rails had been laid down with the new chairs.

Mr. J. Bentley replied that he had laid, approximately, 1,500 to 1,800 feet; and he was now developing a working where the new method would be solely used.

Mr. J. C. Cadman asked what was the cost of an underground chair as compared with a steel sleeper.

Mr. J. Bentley said that the chairs cost about 4d. each and could be used anywhere, while steel sleepers cost from 10d. to 1s. 3d., and could only be used in exceptional cases. Moreover, he found an advantage where the floor was hard, in being able to use shorter and narrower sleepers, and they were not liable to split by having nails driven in the centre.

Mr. H. Johnstone asked what effect rust had upon the chairs when they were required to be taken off.

Mr. J. Bentley said the chairs were tarred, so as to preserve them somewhat against rust, which would only be formed

in very exceptional cases, where the water was of a corrosive nature. This difficulty would be easily overcome by turning back the edges, which were turned over, and lifting the rail off.

Mr. J. R. Haines asked how the joints were made, when two sections of rails, one higher than the other, were connected together.

Mr. J. Bentley said that the same thing happened in any method, and only one section of rails should be used consecutively. As a matter of fact, he used four section of rails, but they were kept separate and one section only was used in each district.

The President (Mr. John Newton), in moving a vote of thanks to Mr. Bentley for his paper, said that the ideas appeared to be perfectly mechanical and applicable.

Mr. B. Woodworth, in seconding the resolution, said that the proposals would bring about an improvement and economy in colliery-working; and no difficulty would be experienced in jointing the simple tongued and grooved type, to suit their use on steep dips, when required.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
DECEMBER 4TH, 1906.

MR. CHARLES PILKINGTON, PRESIDENT, IN THE CHAIR.

The following gentleman was elected, having been previously nominated:—

MEMBER—
Mr. GEORGE ALFRED CHRISTOPHER, Mining Engineer, Wigan Coal and Iron Company, Limited, Standish, Wigan.

DISCUSSION OF MR. SAM MAVOR'S PAPER ON "PRACTICAL PROBLEMS OF MACHINE-MINING."*

Mr. SAM MAVOR said that many of the subjects discussed in his paper were of a controversial character; some of the points indicated a distinct departure from the practices that obtained in certain districts; and, if he was wrong, he would like to hear from those who were continuing the old practices that he condemned.

The PRESIDENT (Mr. Charles Pilkington) said that his company were so afraid of the disadvantages of the bar coal-cutter that they had not tried one. They had several pick, the ordinary disc, and one or two other machines. They thought that, if the bar machine had enough strength, and if the cutters were not liable to be torn out by coming against iron nodules, it would be a very useful tool. He would like to hear whether it was easy to keep the bar machine against the face in mines where the dip was steep, say, 1 in 3½.

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 378; and vol. xxxii., page 391.

Mr. Alfred J. Tonge said that he agreed with Mr. Mavor when he said that it was a mistake for managers to place the coal-cutter in a part of the pit where they knew that it could not succeed, and then expect it to succeed. Managers should take the advice of engineers who had had experience of coal-cutting by machinery, and should work in accordance with their instructions: and he believed that then more coal-cutters would be found at work in mines. Advance in underground mining must almost certainly be accompanied by, and accomplished through, the introduction of machinery; and he thought that the coal-cutter would bring forward the better conditions that many managers were trying to get. He rather disagreed with Mr. Mavor's remarks about an increase in the number of gate-roads. Mr. Mavor said that, if more coal was taken down a gate-road, that was sufficient justification for making other gate-roads. He (Mr. Tonge) thought that such a statement should be qualified by many other conditions; but he was sure that it was not quite right to say that an added gate-road was justified according to the amount of coal that went down it. While gate-roads were convenient for filling the coal quickly, they also meant greater areas of exposed surface, and therefore greater liability to accident. He rather preferred, where possible, a reduction in the number of drawing roads and the carrying of one main road in each district.

[redacted]

clusion that the machines tried were not suitable for their purpose. They had, however, benefited from their experience, and they hoped at some future time to be able to adopt the use of mechanical coal-cutters on a large scale.

The PRESIDENT (Mr. Charles Pilkington) said that a young man, who had been trained to work with machines, would get better results from any coal-cutter than an older man who approached the subject with fixed ideas. The colliery manager and the workmen should both be trained to the work. He might mention that, in using a compressed-air coal-cutting machine, the noise of the exhausted air was confusing to those working near it.

Mr. SAM MAVOR, replying to the discussion, said that, although his paper was not written in special advocacy of the bar type of machine, he might be permitted to say that the President's fears as to the strength of the bar machine were unfounded, and that the low cost of repairs was freely acknowledged bv those who had experience of it. Ironstone-nodules of small size were not troublesome; and, if of large size, the bar machine would, if the head-room permitted it, cut over them; or the bar could be swung out of the holing, the machine drawn past the obstruction, and the bar cut in again and the work would be continued; but, if a disc machine came into contact with an obstruction, considerable time was lost. With regard to the inclination, he had quoted a case in his paper, in which 1 in 3½ was mentioned; that was the maximum inclination with which he had had to deal. When cutting across the dip (the face being advanced to the rise), no machine was easily kept up to the face, owing to the constant thrust upon the props due to the weight of the machine, but the bar type presented no special difficulty in this respect. With regard to the width between the gateways, he (Mr. Mavor) thought that the practice in Lancashire and in Yorkshire, in this respect, was at fault, in many cases at least. He admitted, however, that it was impossible to dogmatize in questions of this kind, as every case should be decided in accordance with local factors; but he thought that both in Lancashire and in Yorkshire, the distance between the gate-roads in many cases, might be decreased with profitable results.

The responsibility of using electrically-driven coal-cutters in gassy seams was a question that the mining engineer must

decide; but he submitted that there were ways of overcoming this difficulty. An interesting example had come under his notice within the last few weeks:—In a naked-light pit, a thin seam of coal, about 19 inches thick and of excellent quality, had not been worked because of gas. The proprietors were reluctant to work it, as the use of safety-lamps might have been imposed throughout the colliery. After experience of the use of coal-cutters in other seams, the manager adopted their use in this thin seam also, and, by means of an auxiliary electrically-driven fan, a sharp air-current was sent along the face; the copious ventilation, in the relatively small working-area, dispelling all risk from gas. He did not suggest that this was a panacea for every case where gas was found, but he had little doubt that there were many cases where the adoption of this method would prove advantageous.

In cases where the present output per foot of working-face was small and the cost of maintaining the gateways was large, he felt assured that there was a wide field for economical working by coal-cutting machinery. There could be no doubt, however, unless the old systems of working were altered, that the machines would not be used to the best advantage. The noise created by a compressed-air machine was a perfectly valid objection, but an arrangement had been introduced by which the exhausted air was turned into an enclosed crank-chamber, and thus to a large extent the noise was muffled.

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to try and make record cuts in order to increase the output per cutter. The output might be increased, although that was doubtful, but any reduction in the cost of cutting was more than counterbalanced by the enhanced cost of repairs which increased out of all proportion to the increase in the output, and also by the greater frequency of breakdowns and the disorganization of the whole system which they produced.

Mr. Mavor recorded in Table I.* those costs which were affected by the output per cutter per shift, namely, machine-labour and interest and depreciation of cutter, as about 10 per cent. of the total cost. It was, therefore, evident that an increase of even 50 per cent. in the cutting speed of the machine would only affect the total cost by 3⅓ per cent. It ought to be possible to obtain far greater real savings than this by studying and organizing the other operations which made up the total cost, and Mr. Mavor had gone very fully into the way in which this could be done. There could be no doubt that the commercial failure of many cutters was due to this point not being sufficiently recognized. He thought that makers were somewhat to blame in pandering to the desire of purchasers by boasting of the achievements of their machines in that respect. The electric cutter suffered most from this kind of abuse. The compressed-air machine stopped and refused to move, and there being no flywheel-effect, as in the case of the electric cutter, little or no harm was done to the working parts. In this respect, the three-phase machine was superior to the direct-current, and what many people formerly regarded as a vice was in reality a virtue. This tendency of the three-phase machine to pull up when overloaded certainly did prevent the machine from being abused to the same extent as the direct-current—actual experience shewing that the cost of upkeep was distinctly less per ton than with the direct-current machine.

He (Mr. Shaw) had had an opportunity of comparing the working of two similar cutters by the same makers, a three-phase and a direct-current, both cutting to the same depth in hard fire-clay in the same seam. The direct-current machine was driven at the highest possible speed, and the average cut per shift was about 60 per cent. greater than with the three-phase machine: it being impossible, for the reason stated above, to drive the

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 388.

latter at greater speed. The wear-and-tear on the gearing, shafts and bearings was at least four times as great in the direct-current cutter. Shafts which were never bent or strained in the three-phase machine continually gave trouble in the direct-current cutter, and bearings and gearing, which only lasted weeks in the latter, lasted as many months in the other machine.

With regard to the actual cost of picks and repairs, Mr. Mavor's figures seemed very low. The results at Hulton colliery for the same items, taken over a period of three years with a number of cutters, both direct-current and three-phase, working in seams ranging from 23 to 48 inches, show a minimum cost of 6·4d. per ton; and, during one year, the cost had been as high as 11·4d. for a group of five machines. The accounts from which these costs were taken had been most carefully kept and included all wages, material and stores chargeable to the repairs and maintenance of the coal-cutting machines.

Mr. Mavor suggested a system of periodically overhauling coal-cutters after the manner of rolling stock; and this was no doubt an excellent idea where the number of machines in the same mine warranted it. A fairly successful system was to give a fitter charge of two coal-cutters, not necessarily in the same mine, and to make him responsible for keeping them in proper working order. It was his duty to go down and see the cutter actually working at least every other shift; and this, in addition to giving him the opportunity of seeing the working parts in [redacted]

cases of bearings being completely worn out in a few days' time owing to neglect of lubrication, followed by the impossibility of effective lubrication after the bearing clearances had become excessive. Gearing, too, very rapidly deteriorated after the relative position of the shaft had been allowed to alter owing to wear in the bearings. With bevil-gearing this was particularly the case, and he had recollection of two bevil-wheels, costing something like £10, completely ruined in three shifts owing to the want of proper adjustment. In his experience, bevil-gearing required a great deal of skill and intelligence to adjust; its use in coal-cutters should, he thought, be avoided as far as possible, and, where it was used, proper provision should be made for taking up the end-thrust. This latter was a point to which many makers seemed to pay insufficient attention. He thought, also, that all gearing, wherever possible, should be enclosed and run in a thick oil-bath. Mr. Mavor pointed out that the coal-cutter was a machine-tool of special design, working under exceptionally trying conditions. In his experience, the fitter who was responsible for repairing it should be highly skilled and intelligent, and should if possible have had some experience of the making of machine-tools. Mr. Mavor advised care in the use of lubricants. The ordinary cheap engine-oil, as used for colliery-purposes, was certainly useless for lubricating anything but the slowest running shafts of coal-cutters; and when melted with a large proportion of solidified oil, it was found very satisfactory for use on enclosed gearing.

Mr. Mavor stated that the alternating-current squirrel-cage motor, with the switch submerged in oil, afforded the greatest security, but that the use of oil in switches should be avoided if possible. Why should it be avoided? He had had such a switch in use on a coal-cutter for three years, he had had absolutely no trouble due to the oil, and he could state that it was the most satisfactory switch that he had used on any coal-cutter. So long as the oil-switch was designed to have a proper head of oil above the sparking points and the insulation of the switch and leads was of such a nature that the oil had no deteriorating action on it, the oil-switch was, in his opinion, the best switch for underground alternating-current work. There was the objection that the oil might leak or waste away, but this should not occur in any properly-designed switch; and it was not so serious a difficulty

as that of keeping intact the lid-joint of the ordinary coal-cutter switch.

Most people would agree with Mr. Mavor's statement that the chief risk attending coal-cutters lay in the trailing cable, and this, he thought, pointed to the moral that these cables should be carefully designed and made of the best material. Cheap low-grade cables should not be tolerated. He formerly had had serious trouble with the trailing cables, chiefly owing to the unsuitability of their design, but he had now used for several years cables made to his own design, with entirely satisfactory results. The main features of the construction of these cables were as follows:—A thick padding surrounding each conductor over the insulation; a copper-wire armouring, of small gauge, serving as an earth-shield; and an outer braiding of hard and durable waterproofed cord. These cables had a long life, were exceedingly flexible and handy, and were almost proof against breakdown due to falling materials and similar damage.

With regard to power-supply, Mr. Mavor pointed out the high cost of generating when power was produced by an independent plant put down for coal-cutting only. Where a power-company's supply was available, there was little doubt that power for this purpose could be bought more cheaply than it could be produced by an independent supply; and where electric power was used for other purposes, if the total amount was comparatively small, and the demand was intermittent and of a highly fluctuating character, the purchase of power would in many cases be the

DISCUSSION OF MESSRS. W. N. ATKINSON AND A. M. HENSHAW'S PAPER ON "THE COURRIÈRES EXPLOSION."*

Mr. A. M. Henshaw, after giving a detailed description of the explosion, said that the pits produced little fire-damp, and the best evidence of that was that none was found after the explosion. When the members considered the area covered by the explosion, it was impossible to believe that even a sudden outburst of fire-damp could have fouled so extensive a range of workings, and caused such an explosion as would account for all the effects observed. The roads were dry and dusty, especially the parts traversed by flame. The disastrous result was to be attributed to coal-dust alone.

Before the authors' visit, some of the main roads had been cleaned, without indications being recorded. They traced the indications to a common source, and this led them to the north side of No. 3 pit at the 1,070 feet (326 metre) level. On May 18th, one of the writers went into the road in the Marie seam from the Joséphine seam, and found leading indications; and on May 22nd, Mr. Heurteau found a blown-out shot-hole in the face of the Lecœuvre heading in the Joséphine seam. This shot-hole, as the point of origin, was consistent with all the other indications found. The most probable explanation was that the shot in question had missed fire on the previous day; that at the time of the explosion the men were engaged in cutting out the shot; and that in doing so they struck the detonator and exploded the charge. He (Mr. Henshaw), therefore, attributed the explosion to a blown-out shot and coal-dust.

He (Mr. Henshaw) hoped that his brief remarks would enable the members to follow the discussion with interest. He directed particular attention to the important lesson to be drawn from the disaster, that the great extent of the explosion and the terrible loss of life were due to the presence of dry coal-dust in the roadways and workings of the mines; and in this, the most disastrous explosion ever recorded in the history of coal-mining, the dangers of coal-dust were, in his opinion, most clearly demonstrated.

Mr. Henry Hall (H.M. Inspector of Mines) said that it was

* *Trans. Inst. M. E.*, 1906, vol. xxxii., pages 439 and 340.

absolutely necessary that all the facts should have been brought before the members in the interests of the British mines. The members would all agree that the enquiry had been put into most excellent keeping, in the hands of Mr. Atkinson and Mr. Henshaw. It remained for the members to enquire into the matter fully. He hoped that the result would be that some steps would be taken such as would render so appalling a disaster impossible in this country. So far as the criticism of the paper was concerned, it struck him as most singular that the whole of the information depended upon what the authors thought themselves. When they had an enquiry in Great Britain, an endeavour, as far as possible, was made to get information from those who worked in the pit on previous days, and from any of the survivors. Information of that kind was absolutely absent in this enquiry, and that he thought was possibly the greatest drawback that could be mentioned with regard to the enquiry itself. The paper itself was most complete and reflected great credit on the authors. Speaking generally, he (Mr. Hall) thought that the conclusion of the authors of the paper was right—that the disaster was caused solely by coal-dust—but the details were open to criticism, where, for instance, they endeavoured to fix the origin of the explosion. The members all knew that this was most difficult, and it very seldom had been done with absolute certainty. He thought, however, that the authors could be excused if they had not quite satisfied the members with regard to the site of the explosion. They had

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experimental station, not 150 feet long but 1,500 feet long, and see whether that model gallery could be blown up by coal-dust in the way suggested. If it could not be blown up in this way, then mine-owners ought not to be called upon to undertake the precautionary watering of their mines. He was afraid that mining engineers in France were unprepared for such an explosion as that which occurred; and it seemed to him that they had very little knowledge of how to proceed after the disaster, and many steps were taken of very doubtful utility. He was not quite certain that mining engineers in Great Britain were in a much better position. When an explosion occurred in this country, there was no one upon whom the duty devolved of saying what steps should be taken to rescue those left in the mine. He thought that some action should be taken, so that some person or some committee should be consulted before any mine was closed, while men dead or alive remained in it. To put the responsibility, however, solely on H.M. inspector of mines was almost more than any man should bear.

Mr. JOHN GERRARD (H.M. Inspector of Mines) congratulated the authors on the success which they had attained; and the fulness of the information given proved the immense pains that they must have taken. It was fitting that such a terrible catastrophe, the greatest in the annals of mining, should be thoroughly enquired into by British mining engineers, and he thought that it would be impossible to have found anyone better qualified than the authors of the paper. One could not but be struck by the extraordinary facilities rendered them: the owners of the collieries, their engineers, and the inspectors of mines must have received the authors with open arms; and for his part, he was anxious that this should be fully recognized.

The cause of the immense loss of life at Courrières opened out a wide field for discussion—the shafts, the roadways connecting the workings with the shafts, coal-dust, explosives, underground fires, discipline, mines-inspection, etc. If there was anything to be learned from that terrible disaster, it was their duty to apply the lessons to British mines with a view to the prevention of a similar loss of life in this country. Mr. A. M. Henshaw had spoken of the cause of that disaster as being a blown-out shot. He (Mr. Gerrard) was not going to differ from him, but he would

like to examine the question for a moment, because on previous occasions shots had been called blown-out shots, which, to his mind, were not blown-out shots at all. Could this be directly called a blown-out shot? In point of fact, it would not have been fired if the detonator had not been exposed. It was supposed that the detonator was struck by a pick. The starting of the force in this case was quite different from that seen so many times at the start of a coal-dust explosion. The smashing of the air-pipe, which took the air from the face, was in itself interesting; and, if fire-damp had been found, the members could understand the bursting of the pipes in that extraordinary outward manner, or coal-dust in the pipe might explain it. He regretted that there was no information with regard to the amount of ventilation that passed through the mine. He asked whether the Government officials, in taking possession of the mine, acted on their own initiative absolutely or whether they consulted with the engineers.

Mr. A. M. HENSHAW replied that they consulted with the engineers.

Mr. GERRARD remarked that it was foreign to his experience. It had always been customary to work together with the engineers that assembled; and nothing was done without the approval of the engineers. The direction of operations by Government officials seemed to be open to very serious question, and was extremely undesirable. One of the most interesting points in [redacted]

was burnt by the ignition of fire-damp by a naked light, and some fire-damp was met with in the lowest level in Nos. 4 and 11 pits in 1903, 1904 and 1905. It seemed that all hope of any survivors being in the pit appeared to have been abandoned up to the time of the appearance of 13 men, twenty days after the explosion. It was stated that the blast did not appear to have been so violent as in some British explosions, yet that there were traces of violence in some parts and notably in the intake-air-ways. Then in connection with the fire, which was discovered in the Cécile seam before the explosion, it was a rather strange coincidence that the stoppings were closed just a little time before the explosion took place. The mode of re-entry after the explosion did not meet with general approval. Four days after the explosion, there was a general strike of the miners throughout the Pas-de-Calais district. A new trade-union was formed, and five days afterwards the Minister of the Interior had an interview with the officials. The iron door for passage, which was introduced in each stopping, when extinguishing the first fire in the Joséphine seam gave rise to the allegation that the restoration of the mine was more the object in view than the rescue of the entombed miners; and that resulted soon afterwards in a change being made. Bitter attacks found expression against the explorers, although some of them lost their lives in their endeavours. The miners' agents on the Commission of Inquiry made a premature minority report, throwing the responsibility on the owners, alleging repeated warnings to them that the mine was dangerous. The majority report, however, followed and cleared the engineers of all blame, and testified to their exertions. A member of the Mines Commission of the Chamber of Deputies visited the mine and took evidence; and, afterwards, in a debate in the Chamber, criticized the owners, to the effect that the State engineers were insufficient in number and the functions of the miners' agents too restricted,—the result being to rely upon the declaration of the Government to ascertain the responsibilities, and, if occasion arose, to enforce all requirements of the law. Meanwhile, the *Parquet* at Béthune acquitted the State engineers of all blame in the recent operations; and it was stated that medical examination of the bodies had established the opinion that of the bodies recovered none, so far as ascertained, had survived the day of the explosion.

For the purposes of his report, Mr. W. N. Atkinson went underground eighteen times between May 4th and 18th, and between June 22nd and 29th, the first view being made 55 days after the explosion. Mr. Henshaw also seemed to have made ample views. Before the commencement of the view, therefore, exploration had effected many changes, and road-ways formerly dry and dusty had become wet with water. Steam also from the water used in extinguishing the first fire in the Joséphine seam had moistened some roadways.

After tracing the direction of the explosion, the writers came to the conclusion that it was caused through a blown-out shot in the Lecœuvre heading, that probably the shot was fired while the men were attempting to cut it out, and that in all probability it was a dust-explosion without the presence of gas. The writers, however, agreed that the actual cause might never be ascertained; and, in coming to this conclusion, they gave some good, although not completely convincing, reasons. The mines were singularly free from fire-damp, and were chiefly worked with naked lights. Partially coked dust was observed in the parts traversed by flame. The first fire in the Joséphine seam was attributed to the flame of the explosion; and the second fire was attributed to the same cause. The former fire was found in the return-airway of the Cécile seam three or four days before the explosion, the explosion following soon after the closing of the stoppings, and as the explosion did not appear to have occurred at the fire, it was supposed that gas was distilled from the fire into the

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apparently that ignition might light coal-dust. If fire-damp aided, naked lights were unsafe in dusty mines, unless watered. The explosion opened out a wide field for experiment and discussion. The experiments made by Mr. Henry Hall* with gunpowder and other explosives fired from a cannon into sprinkled coal-dust in an old shaft showed clearly that such dust could be ignited and some force developed, yet in these experiments as seen by himself the force was less destructive than in ordinary fire-damp explosions. Similar lack of vigour was noticed at the Courrières collieries. He (Mr. Dickinson) had produced a spark many times from compressed air alone, but never repeated from the same body of air once exploded. It would be interesting to know the amount of ventilation at the Courrières collieries, as it was not stated by the authors. Also, whether among such extensive workings any new opening was being made on the dip, from which atmospheric pressure might have helped fire-damp to ascend into the workings. Such sudden appearances had occurred; or the stoppings, shutting off the fire in the Cécile seam, might have disarranged the ventilation. Of the total number of safety-lamps enjoined by the regulations, 250 were used in Nos. 4 and 11 pits and the other 90 in No. 2 pit. All these lamps were in use in the pits that exploded. The rescue-operations had been criticized, but he would say that such operations required nerve and care. As to this point it should be noted that after-damp and fire-damp are poisonous gases unless diluted, and therefore pits containing such might not be entered with impunity for a longer time than a person could hold his breath unless he was provided with some reliable breathing apparatus. It was satisfactory to know that the report of the officials of the Courts of Justice on the responsibilities and points of law was expected to contain much valuable evidence.

The PRESIDENT (Mr. Charles Pilkington) remarked that there appeared to have been a certain amount of interference by the State engineers in the management of the pits, with which he certainly did not agree. He could hardly believe that it was a

* *Report of Experiments to test the Effects of Blasting with Gunpowder in Dry and Dusty Colliery Workings in the Entire Absence of Fire-damp*, by Mr. Henry Hall, 1890; and *Report made by desire of the Secretary of State to the Royal Commission on Explosions from Coal-dust in Mines*, by Mr. Henry Hall, 1893 [C.—7,185].

fact. It was the last thing that a British inspector of mines would desire. The engineers and managers, responsible for a pit before an explosion, were the men to take charge of it after the accident. H.M. inspectors of mines were, of course, always present on such occasions, and rendered valuable assistance, and their advice was always gladly received; but, if they took the management out of the hands of the colliery engineers, he could quite understand that things might go wrong.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
JANUARY 8TH, 1907.

MR. CHARLES PILKINGTON, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—
Mr. JAMES FILES, Mining Engineer, 402, Bolton Road, Clifton, Manchester.
Mr. T. OLIVER CROSS, Mining Engineer, 77, King Street, Manchester.

ASSOCIATE MEMBER—
Mr. WILFRID BENJAMIN WAINEWRIGHT, Los Angeles, California, United States of America.

Mr. WILLIAM WATTS, delegate of the Society to the meeting of the Corresponding Societies of the British Association for the Advancement of Science, held at York on August 2nd and 7th, 1906, read his report of that meeting.

HORIZONTAL AND VERTICAL SECTIONS OF COAL-MEASURES FROM RISHTON, LANCASHIRE, TO PONTEFRACT, YORKSHIRE.

Mr. JOHN GERRARD (H.M. Inspector of Mines) exhibited horizontal and vertical sections of the Coal-measures from Rishton, in Lancashire, to Pontefract, in Yorkshire. The section had been prepared, on the Lancashire side, by Mr. William Pickup, of Rishton colliery, who had shewn the position of the Upper and Lower Mountain mines, in connection with the district of Rishton; by Mr. George Elce, who had shewn the position of the Arley mine, and the Upper and Lower Mountain mines at Altham; and by Mr. Edgar O. Bolton, of Burnley colliery, who

had shown in a very clear manner the position of the seams in the Burnley district. The first portion was carried to the end of the Lancashire basin, then came the moorlands through the Millstone and other grits until the Yorkshire coal-field was reached. The section shewed the Halifax seams which were said to correspond to the Mountain mines of Lancashire; it was extended to Bradford, Low Moor and Cleckheaton, until it included the higher seams, such as the Middleton Main, which might or might not have some relation to the Arley mine; and finally it showed the thicker seams near Normanton, and so on to Pontefract. The section was really the outcome of a discussion which took place some six or seven years ago. A Committee was appointed of members of this Society and of the Midland Institute of Mining, Civil and Mechanical Engineers, to work together and try to correlate the seams of Lancashire with those of Yorkshire. He (Mr. Gerrard) did not say that the section carried matters very much forward in connection with the work of correlation, but it was a first step, and shewed the position of the different coal-seams; and upon this section mining engineers could advance their favourite theories so far as they chose to go. The section now exhibited belonged to friends in Yorkshire, and before handing it over to them he thought that it might be shewn at this meeting. The distance covered by the section was about 60 miles. The absolute break between the two districts was clearly shown. He was very grateful to the gentlemen he had named for the work that they had done.

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fordshire; and with this key to their sequence it was comparatively an easy matter to go to the other coal-fields and see how far the sequence held in them. The presence of these different forms was a true indication of the coal-seams in their vicinity. It was everybody's experience that one never found anything unless one looked specifically for it, and that one always found what one looked for specifically. If these forms were diligently looked for, he believed that they would be found. In Yorkshire, workers were taking up this matter in earnest, and he did not doubt that in a very few years they would be able to add very much to their store of knowledge of this question. Mining engineers required some scheme for the unification of their knowledge of the Coal-measures, so that when a man, who had been trained in one coal-field and knew its sequence, went to another coal-field he could, almost at once (if the knowledge were codified and registered and recorded), pass from the sequence of the new coal-field to that with which he was already familiar.

To some extent that need was met by classification of the Coal-measures, and classification had been taken up by different workers and based on different grounds. Almost everybody had adopted the Upper, Middle and Lower Coal-measure divisions until the last few years. That classification had the advantage of being rough-and-ready, but a division, a threefold division, of 3,000 feet or more of Coal-measures was not, and never could be, refined enough for the practical needs of the mining engineer, who wanted to know with much greater particularity where he was, in proving faults, in putting down bore-holes, and in sinking, than simply to know whether he was in the Upper, Middle or Lower Coal-measures. Another disadvantage of that scheme was that the Upper, Middle and Lower divisions of one district were not correlative with the Upper, Middle and Lower divisions respectively of other coal-fields. That was a serious disadvantage; people acquainted with the characteristics of, say, the Middle Coal-measures of one coal-field, when they went to another coal-field were often misled. They found that certain organic forms were either present in, or absent from, the Middle Coal-measures in the new district, and the result was that they had to get their bearings afresh, *ab initio*, for the new coal-field. The Upper, Middle and Lower terms had been adopted by palæobotanists; but the trouble was that they had so many transition

series. As a matter of fact, the Coal-measures were one great transition series so far as fossil plants were concerned, and that introduced an amount of uncertainty into the correlation by plant-remains that was most perplexing to the practical mining engineer. Then, there was a recent classification based on colour, such as a red, or a grey, or a pale-grey, or a red-and-grey series. Now, no classification of the Coal-measures based on colour could be of much service to the mining engineer. Colour was, geologically, one of the most uncertain things, depending, as it did, so largely on fortuitous changes produced by weathering, and it was unsafe to base any classification of the Coal-measures on the fact that a majority of the strata were either grey or red. Practical mining engineers had attempted the correlation of the coal-seams of individual fields by reference to their physical characters, and by comparing sections of coal-seams of a certain thickness and quality, and lying at a certain depth above or below other seams of a certain thickness and quality. They had, on such data, joined up one seam with another, and that was what he called "the arm-chair method of correlation." It was based on the variable data above-mentioned; and a classification that was based on such variable data could not be reliable. Eventually he had been driven to try the system of correlation by the mollusca.

There was, he (Mr. Stobbs) found, considerable scepticism as to the value of these fossil shells, and it rested with those who [redacted]

aright, would convey useful knowledge as to the true horizon of the strata.

Instances where the mollusca would be of special service, and examples where they had already proved so, might be cited: in coal-fields like those of Lancashire and Yorkshire, where the Coal-measures were overlain unconformably by newer rocks (Triassic or Permian), great care should be exercised when sinking through them to the underlying Coal-measures. It was of the first importance that the mining engineer should know, when he had sunk or bored through the former, the horizon reached in the Coal-measures, and undoubtedly mollusca would be able to help him most. His (Mr. Stobbs') confidence on this point was based on experience gained in mining operations, as he had proved the utility of mollusca in determining horizons even in borings. In the Cheadle coal-field, a bore-hole was put through measures which had never been passed through before and were not exposed at the surface, and it was important that the parties responsible for the bore-hole should know what seams had been passed through. The fossils found in a core, 3 inches in diameter, enabled him to identify the Four-feet seam; and a further examination of the cores shewed a new marine bed about 81 feet above the Dilhorne coal-seam of that district. About a year later, when a shaft was being sunk in the same coal-field, he found the same marine bed, and he was able, therefore, to state that 81 feet lower down they would get the Dilhorne coal-seam; and some months later that coal was found at that exact depth. Of course, great care was required; the shells should be authoritatively recognized, and their diagnostic value should be properly assessed.* He (Mr. Stobbs) appealed to the younger members to assist him, as workers were needed in every coal-field. In taking up this work they would have the satisfaction of feeling that they were making discoveries and adding to scientific knowledge, and that they were acquiring skill in recognizing the different forms and in looking for them. He assumed that the members would agree that the engineers of the future had their work cut out for them, and it was the more necessary that in this generation they should settle the question of the distribution of mollusca in the Coal-measures, so that this problem, at any rate, would not be a future source of uncertainty and anxiety.

* *Trans. Inst. M. E.*, 1905, vol. xxx., page 456.

In the future, as a result of accurate accumulated work in different coal-fields, this question, now in portions of the sequence in a state of undesirable uncertainty, would be so established that it would be possible to define the position of any seam or band in the Coal-measures with the certainty that one now, in the case of winding-engines of given power, determined the quantity of coal that could be raised from a certain depth in a given time.

Mr. H. Stanley Atherton urged the desirability of forming a band of workers in this field of enquiry who would render to Lancashire something of that service which Dr. Wheelton Hind and Mr. J. T. Stobbs had rendered to North Staffordshire.

Mr. A. Rushton exhibited fossils found in the roof of the Wigan Nine-feet or Trencherbone seam, at Maypole colliery, Abram. They formed part of a shell-bed lying on the roof, within 3 feet of the coal-seam. He had worked the Trencherbone seam in the Manchester district, and the Wigan Nine-feet in collieries lying to the north of Wigan, but he had not found these shells previously in the roof of that coal-seam. They appeared to be of a local distribution at Maypole colliery.

Mr. William Ollerenshaw remarked that mining engineers and others who had experience in coal-mining were agreed that a more reliable method and system of correlating coal-seams was required, as it had been repeatedly proved that the present system was unreliable. The Two-feet or cannel coal-seam, in the [redacted]

ceed on the lines advocated by Mr. Stobbs, it would prove a much safer method, and that the present unsatisfactory correlation of coal-seams would be improved in the future.

Dr. Wheelton Hind said that he was pleased to find that his work on the Coal-measure mollusca of twelve years ago was bearing good fruit, and delighted that Mr. Stobbs was proving the value of these fossils in practical mining. He (Dr. Hind) approached these fossils from a biological standpoint at first, and it was only later on that the accumulation of facts of distribution shewed him the value of certain species as accurate indices of horizons in the Coal-measures. He had attempted to sketch out the distribution of the genera *Carbonicola, Anthracomya* and *Naiadites*, as far as was then possible, in the strata of the various coal-fields of Great Britain. One zone of great importance, characterized by the presence of *Anthracomya Phillipsi*, denoted the top of the workable coal series in most of the coal-fields. At Bristol, a higher zone occurred, but this was recognized by its flora. Marine could be readily distinguished from non-marine bands, as the structure of marine shells, their ornament, large teeth, and anatomy differed markedly from those of fresh-water forms. In marine bands, Gasteropoda, or coiled shells, Cephalopoda or chambered shells, and Brachiopoda occurred with lamellibranchs, but were never found in freshwater beds where the shells belonged to the *Unio* type, just as in the rivers and lakes of to-day.

Mr. William Pickup said that a correction should be made in the paper.* The words " Upper Mountain " should read " Upper Foot." The marine shells referred to were not found above the Upper Mountain, they were always found above the Bullion or Upper Foot coal, a seam lower in the series than the Upper Mountain, and generally found by itself, but sometimes it combined with the Lower Mountain mine.

Mr. John Gerrard sincerely hoped that some of the younger members would take up this work. He was quite sure that if they once got interested in it they would go on and never regret their perseverance. The work was not only interesting, but exceedingly valuable in connection with mining.

* *Trans. Inst. M. E.*, 1905, vol. xxx., page 449, Lancashire coal-field, paragraph (*d*).

Mr. WALTER BALDWIN wrote that Mr. Stobbs and Dr. Wheelton Hind were to be congratulated upon the good work that they had done in Staffordshire. They had shewn that "zoning" the Coal-measures could be carried out upon a sound basis. He regretted that, in the Lancashire and other coal-fields, mining engineers had been slow to search for and to adopt these useful indices. The key which Mr. Stobbs and Dr. Wheelton Hind had discovered in Staffordshire would, he believed, undoubtedly open the doors of other coal-fields. He regretted that in the Lancashire coal-field, the material, at present to hand, was scanty, and the field-workers were few; and, until both were increased, the value of mollusca would not appeal to the practical man. He hoped that the effect of Mr. Stobbs' paper and the present discussion would be that all members, who were engaged in sinking or driving drifts, would look out for fossil mollusca; let them note as nearly as possible the vertical distance above or below the nearest seam of coal, and submit the fossils to some recognized expert for determination. The result of such observations, when collected, would prove most useful and of great value to all engaged in the coal-mining industry as well as to the general geological student.

Whilst engaged as resident engineer, a few years ago, in sinking a deep puddle-trench for a reservoir, he (Mr. Baldwin) encountered three thin coal-seams associated with a marine band containing *Goniatites*, *Orthoceras*, *Pterinopecten*, etc. He was thus able to refer the coals to the Holcombe or Brooksbottoms

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(de Koninck), *O. obtusum* (Brown), *O. Browni* and *O. subsulcatum; Glyphioceras reticulatum* (Phillips); *Dimorphoceras Gilbertsoni* (Phillips); and *Gastrioceras carbonarium* (L. von Buch), and *G. Listeri* (Martin). A very similar assemblage holds good for Starring, Dearnley, Dulesgate and Besom Hill, near Shaw. About 135 feet above the Arley mine at Sparth, near Rochdale,* he (Mr. Baldwin) had found *Carbonicola acuta* in large numbers associated with *C. turgida* (not common) and *C. robusta* (rare); and *Naiadites modiolaris, N. triangularis, N. carinata* and *N. elongata.* These were accompanied by that wonderful collection of Arthropoda discovered last year by Mr. W. A. Parker and exhibited and described by Dr. Henry Woodward at the meeting of the British Association for the Advancement of Science held at York. He (Mr. Baldwin) asked whether any Arthropoda had been found at or about this horizon above the Cockshead coal-seam of North Staffordshire. In his opinion, this horizon ought to be watched at many localities, as well in Yorkshire, as in Nottinghamshire, Lancashire and in North Staffordshire.

Mr. Joseph Dickinson, F.G.S., wrote requesting that the name of the coal-seam with which the well-known fossil-horizon occurred in the Lower series of the Lancashire coal-field, might be corrected in the present paper.† It was erroneously called the Upper Mountain instead of the Upper Foot coal-seam: the Upper Mountain being a seam higher in the series than the Upper Foot seam. In East Lancashire, this well-marked horizon continued over and with the Foot coal alone. But in North Lancashire, the Foot coal dipped down to the Gannister coal, and the two together formed the Four-feet Mountain mine in North Lancashire.

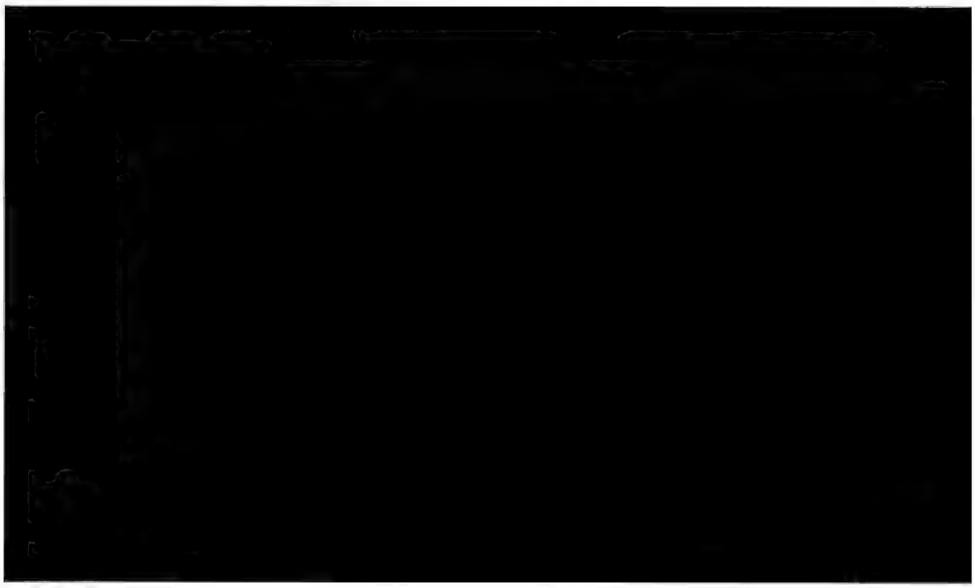
Mr. J. T. Stobbs accepted the correction concerning the use of the name Upper Foot instead of Upper Mountain mine printed in his paper. Referring to Mr. Rushton's remarks, he said that he would like to know whether it had been actually demonstrated that the Wigan Nine-feet seam was the Trencher-

* "Notes on the Palæontology of Sparth Bottoms, Rochdale," by Mr. W. Baldwin, *Transactions of the Rochdale Literary and Scientific Society*, 1903-1905, vol. viii., page 82; and "*Bellinurus bellulus* from Sparth, Rochdale," by Mr. W. Baldwin, *Transactions of the Manchester Geological and Mining Society*, 1903, vol. xxviii., page 198.

† *Trans. Inst. M. E.*, 1905, vol. xxx., page 449, Lancashire coal-field, paragraph (*d*).

bone seam. He appreciated Mr. Ollerenshaw's reference to the necessity of having some more reliable guide to the nature of coal-seams than the lithological features that had hitherto been so much trusted by mining engineers.

The President (Mr. Charles Pilkington) suggested that a committee of the members should be formed to carry on these investigations.



THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, DECEMBER 8TH, 1906.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 24th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. WALTER ROBERT ABEL, Mechanical Engineer, 8, Queen's Gardens, Benton, Newcastle-upon-Tyne.

Mr. EVAN COCKBURN, Colliery Manager, Waldridge Colliery, Chester-le-Street.

Mr. JOHN ALLAN CUNNINGHAM, Inspector of Boilers, P.O. Box 59, Dundee, Natal, South Africa.

Mr. GEORGE DIXON, Colliery Manager, c/o Messrs. Bird and Company, 100 and 101, Clive Street, Calcutta, India.

Mr. CLEMENT JONES, Colliery Manager, Neath Colliery, Cessnock, New South Wales, Australia.

Mr. GEORGE HENRY HALL SCOTT, Mining Engineer, 3, Eldon Square, Newcastle-upon-Tyne.

ASSOCIATE MEMBERS—

Mr. WILLIAM EASTWOOD, 93, Scar Lane, Milnsbridge, Huddersfield.

Mr. JAMES PARMLEY GRAHAM, 26, Cloth Market, Newcastle-upon-Tyne.

Mr. ROBERT NORMAN REDMAYNE, Woodside, Low Fell, Gateshead-upon-Tyne.

ASSOCIATES—

Mr. TOM STEWARTSON COCKBAIN, Under-manager, Usworth Colliery, Washington Station, S.O., County Durham.

Mr. THOMAS CRAWFORD, Surveyor, The Croft, Wrekenton, Gateshead-upon-Tyne.

Mr. JOHN GEORGE GUY, Under-manager, Manor House, Wardley Colliery, Newcastle-upon-Tyne.

Mr. ANDREW PATTISON, Back-overman, Clara Vale Colliery, Ryton, S.O., County Durham.

Mr. HENRY RICHARDSON, Master-shifter, Clara Vale Colliery, Ryton, S.O., County Durham.

Mr. WILLIAM RIDLEY, JUN., Surveyor, Mary Pit, Blaydon-upon-Tyne, S.O., County Durham.

STUDENTS—

Mr. ANDREW D. BRYDON, Mining Student, Millburn, Darlington.

Mr. ARCHIBALD FELCE DICK-CLELAND, Mining Student, 9, Cross Street, Camborne.

Mr. JOHN ALFRED LISTER, Mining Student, 18, Baff Street, Spennymoor.

Mr. THOMAS JOHN MUSE, JUN., Mining Student, Cornsay Colliery, Durham.

Mr. ROBERT POWLEY WILD, Mining Student, 9, Cross Street, Camborne.

DISCUSSION OF DR. J. A. SMYTHE'S PAPER ON "DEPOSITS IN A PIT-FALL AT TANFIELD LEA, TANTOBIE, COUNTY DURHAM."*

Dr. J. A. SMYTHE submitted samples of the deposit, a black gelatinous substance or "black stuff," found under an old peat-bed in a pit-fall at Tantobie. It was distinguished by a concentric arrangement of layers and conchoidal fracture, and evidently corresponded to the *saprokoll* of Prof. H. Potonié. From its occurrence only beneath the peat-bed, it was evidently derived from the peat, a view which was strengthened by its similarity in composition ; and the higher nitrogen-content was also in har-

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as a transition-product between the cellulose of plants and some of the more important constituents of coal. According to Prof. H. Potonié's theory, it represented the raw material from which cannel-coal was made.

Prof. Henry Louis said that he had been very much interested in Dr. Smythe's work, which demonstrated a possible mode of origin of coal. The experiments of Dr. Martin Ekenberg, Stockholm, less known in this country than they deserved to be, shewed that it was possible to convert peat into a substance practically indistinguishable from ordinary coal, by the action of superheated steam at high pressures. Those experiments, taken in conjunction with Dr. Smythe's communication, seemed to offer some clue to the processes which converted woody and peaty matter into coal.

Prof. P. P. Bedson congratulated Dr. Smythe on what must be considered as a very valuable and interesting contribution to the subject of the conversion of woody matter into coal.

The President (Mr. J. H. Merivale) said that Dr. Smythe appeared to have supplied the missing link between vegetation and coal.

DISCUSSION OF MR. W. MAURICE'S PAPER ON "A RATEAU EXHAUST-STEAM-DRIVEN THREE-PHASE HAULAGE PLANT."*

Mr. W. C. Mountain believed that there was an important future for the Rateau turbine, in connection with the utilization of the exhaust-steam from winding-engines. It was stated that one kilowatt could be produced for every 38 pounds of steam at atmospheric pressure, exhausted to a vacuum of 26 inches from a winding-engine; and, consequently, if the winding-engine used more than 38 pounds of steam per horsepower, more power would be developed by the exhaust-steam than by the engine. In a plant of this description near Doncaster, it was hoped that 1,000 kilowatts would be produced from the exhaust-steam of two winding-engines, an additional amount of power from the

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 118.

exhaust-steam that would otherwise have been wasted. He understood that the plant at Hucknall colliery, described by Mr. Maurice, was giving very economical results.

The President (Mr. J. H. Merivale) remarked that the arrangement seemed to be taking away the character of the old winding-engine, in regard to which they had hitherto prided themselves that it was the most wasteful of steam of any kind of engine.

EXPERIMENTS ILLUSTRATIVE OF THE INFLAMMABILITY OF MIXTURES OF COAL-DUST AND AIR.

By P. PHILLIPS BEDSON, D.Sc., and HENRY WIDDAS, B.Sc.

Some years ago, Dr. Rud. Holtzwart and Dr. Ernst von Meyer described* an apparatus for and a method of testing the inflammability of mixtures of coal-dust and air. Briefly, the apparatus consisted of an arrangement whereby the dust was projected by a blast of air through a gap between two platinum-wires, and thus subjected to a series of electric sparks.

Experimenting in the manner described by Messrs. Holtzwart and von Meyer, and convinced of the utility of this method of examining the question of the inflammability of mixtures of coal-dust and air, the authors have extended and modified the apparatus in such a way as to enable them to study the question on a somewhat larger scale, and at the same time to gain, if possible, information which may prove serviceable in investigating the question of explosions in which coal-dust and other inflammable dusts play a part.

The apparatus consists of a bottle, *a*, about 116 cubic inches in capacity, closed by a stopper, in which are three glass-tubes, one, *b*, connected with a foot-bellows, a second, *c*, connected with a U-tube, *d*, containing mercury and serving as a manometer, whilst the third tube, *e*, is attached by indiarubber-tubing to the explosion-apparatus. The explosion-apparatus consists of a glass-tube, *m*, 1½ inches in diameter, attached to a cubical tin-box, *f*, 4 inches long, provided with mica-windows, *g*, at the back and front, circular openings above, *h*, and below, *i*, and, on either side, cylindrical collars, *j* and *k*, serve as a means of attaching the glass-tubes, *l* and *m*, 1½ inches in diameter. Through the circular opening at the bottom, *i*, the gas-jet, *q*, used to inflame the dust is introduced; or the inflammation may be effected by an electrically-heated coil of platinum-wire, suspended between copper-wires, introduced through *h*.

* "Ueber die Ursachen von Explosionen in Braunkohlen-briquettefabriken (The Causes of Explosions in Brown-coal Briquette Works)," *Dinglers Polytechnisches Journal*, 1891, vol. cclxxx., pages 185 to 190 and 237 to 240.

The method of working is as follows:—A weighed quantity of dust is brought into the wide tube, *m*, on the left side of the box, and the tube is closed by a cork, *s*, carrying the glass-tube, *n*, connected with the compressed-air supply. The air in the bottle is compressed to the desired amount by the foot-bellows, the gas-jet, *q*, having been brought into position in the box, the tap, *p*, is quickly opened, and, by the blast of air, the dust is blown into the flame, *q*, and the behaviour of the dust carefully noted.

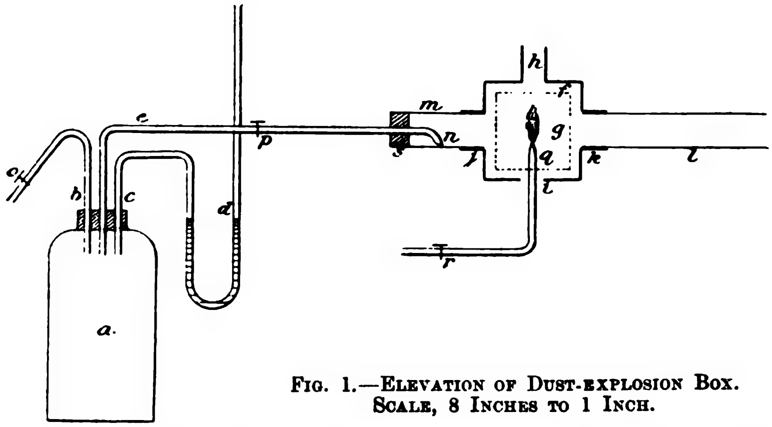

Fig. 1.—Elevation of Dust-explosion Box.
Scale, 8 Inches to 1 Inch.

The first series of experiments shown comprized the ignition of mixtures of finely-ground brown-coal and air by (*a*) electric sparks, (*b*) a platinum-wire heated electrically, and (*c*) a small gas-flame. In the second series of experiments, the behaviour of

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inflammation. The different stages of the burning of a mixture of ordinary coal-gas and air, developing into explosive combustion, was illustrated by an experiment.

Experiments were also shown in which the fact that mixtures of air and dust of combustible materials comported themselves like mixtures of air and a combustible gas was illustrated. In these experiments an apparatus represented in Fig. 2 was used. It consists of a glass-tube, *a*, 1½ inches in diameter and 3 inches long, closed at the lower end by a cork, *b*, through which passed a funnel-shaped glass-tube, *c*, connected with a foot-bellows; the wide end of *c* was covered with cotton-gauze, *d*. The upper end of *a* was covered by cotton-gauze, *e*, kept in position by a metal collar, *f*. On the cotton-gauze, *e*, a quantity of coal-dust, *g*, was placed, and into the collar, a tube, *h*, some 8 or 12 inches long was fitted. The whole apparatus was held in a vertical position.

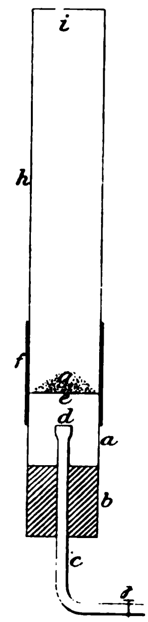

FIG. 2.—ELEVATION OF DUST-EXPLOSION TUBE. SCALE, 4 INCHES TO 1 INCH.

By means of a blast of air from the foot-bellows, a cloud of dust was produced in the vertical tube, *h*, and ignited by a flame brought to the mouth, *i*, of the tube. When the dust was burning at the open end, *i*, the air-current was slackened and the flame was seen to travel down the tube, *h*, igniting the explosive mixture of air and dust in the lower part of the tube. The combustible dusts used in these experiments were coal-dust, finely divided aluminium and lycopodium.

Prof. P. P. BEDSON gave a demonstration with the apparatus described in the paper, prefacing the demonstration with the statement that he had the benefit of the collaboration of Mr. Henry Widdas in this investigation, since Mr. Widdas, as the holder of the Scholarship of the Institution of Mining and Metallurgy given annually to Armstrong College, was enabled to extend his years of study and devote himself to research.

Mr. W. C. BLACKETT asked what result might be expected if the tubes were prolonged so as to have greater resistance, so to speak, in front of the explosion. Would it be expected to develop

a greater pressure of the atmosphere and a corresponding increase in the violence of the explosion? In other words, would the air, if it was at greater pressure, develop a higher explosive effect?

Mr. F. Coulson asked what would be the effect of a continuous supply of coal-dust throughout the full length of the tube, and whether such a continuous supply of dust, if disturbed, would increase the severity of the explosion.

Mr. T. E. Forster asked whether Prof. Bedson proposed to make any experiments, so as to shew what amount of moisture should be present to make the dust non-explosive.

Mr. M. Ford asked what was the condition of the dust, in regard to fineness, that had been used in the experiments.

Mr. P. Kirkup asked, supposing that the tube were considerably lengthened, and had a layer of dust distributed along its entire surface, whether the explosion would extend over the whole distance. He also asked, as regarded the coal-dust which had been used, whether this dust was actually obtained in the mine, and, if so, whether it was obtained from a haulage-way, or return-airway, at the working-face, or elsewhere.

Mr. W. C. Mountain asked whether the coal-dust used in the experiments was actual dust as found in the pit, or whether it had been specially ground for the purpose of the experiments.

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made as to the influence of dant, but he imagined that dant would have a deadening influence. With regard to the effect of prolonging the tubes, the experiments which had been made were not suitable for deciding the point; they required an explosion in a closed chamber.

As to the continuous supply, it would depend on the manner in which the coal-dust was supplied. If the coal-dust was lying on the bottom of the tube, they could fire along the tube without disturbing the dust, but if the dust was disturbed, and was raised in a cloud, firing at the end of the tube would have a very marked effect. In the case of dust lying on the bottom of the tube, the flame would pass over it; but, if it formed a cloud, and was in motion, it was much more readily inflammable. He hoped, at some future time, to be able to communicate the results of experiments dealing with the influence of moisture.

The PRESIDENT (Mr. J. H. Merivale), in moving a vote of thanks to Prof. Bedson and Mr. Widdas for the demonstrations, said that coal-dust was becoming a classic question in connection with Armstrong College, for Prof. Freire Marreco directed his attention to it upwards of 30 years ago, and Prof. Bedson took up the question on the occasion of the explosion of an air-receiver at Ryhope Colliery some 23 years ago. The members were exceedingly indebted to him and his coadjutors, and hoped that they would continue to give them the benefit of their researches for many years to come.

The vote of thanks was heartily adopted.

Mr. OTTO SIMONIS read the following paper on "Liquid Air and its Use in Rescue-apparatus":—

LIQUID AIR AND ITS USE IN RESCUE-APPARATUS.

By OTTO SIMONIS.

Some years ago, the writer had the pleasure of exhibiting to the members a mining rescue-apparatus, fed by compressed oxygen, and it represented one of the first self-feeding rescue-helmets constructed. Since that time, science and practice have continually worked to improve upon this class of life-saving apparatus.

The so-called regenerating appliances, which strove to overcome the short period of the supply of self-feeders by regenerating processes, have, after the efforts of Mr. G. A. Meyer, of Herne, Westphalia, and Mr. E. Giersberg, of Berlin, been brought to the utmost perfection by the Berlin Oxygen Company, and especially after a separation in this firm by the Drägerwerk, of Lübeck. These appliances had, however, the great disadvantages of great weight, high temperature in the helmet, and heating of the air regenerated by a chemical process; in addition, there was the danger, always present, of some of the particles of the absorbent being carried into the lungs and producing serious

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The entire apparatus, weighing about 14 pounds, is easily carried on the back without any encumbrance, and it gives an absolutely pure and deliciously cool air-supply for up to 3 hours' working. It does not contain any chemicals; it is without any complications whatsoever; there is not a single valve in the whole apparatus; and its use does not require any special training.

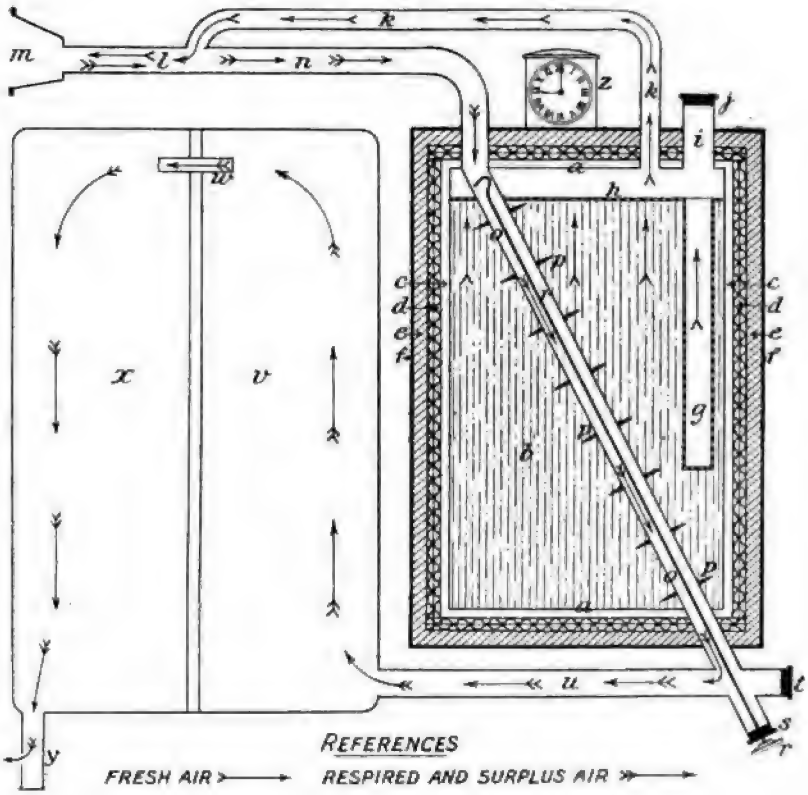

FIG. 1.—DIAGRAM OF THE AEROLITH LIQUID-AIR RESCUE-APPARATUS. SCALE, 6 INCHES TO 1 INCH.

Atmospheric air liquefies at a temperature of $-191°$ Cent., and is compressed to about the seven-hundredth to eight-hundredth part of its original volume. Consequently 1 gallon of liquid air will evaporate into 700 to 800 gallons (110 to 130 cubic feet) of atmospheric air.

This principle has been applied in the following manner:—A solid-nickel receptacle, *a*, packed with asbestos-wool, *b*, in-

sulated against outside and atmospheric influences by a vacuum-space, *c*, an air-space, *d*, a layer of felt, *e*, and a leather cover, *f*, measuring about 16 inches long, 11 inches wide and 4 inches thick, is carried on the back like a knapsack (Fig. 1). The nickel vessel, *a*, has an inlet, *i*, for the liquid air, provided with a screw-cap, *j*. The outlet for the vaporized air is connected by a flexible-metal tube, *k*, to the combined pipe, *l*, leading to the fireman's face-mask or miner's mouth-piece, *m*. The vessel, *a*, is traversed in a diagonal direction by a tube, *o*, fitted with radiators, *p*, connected at the upper end by a flexible well-insulated metal-tube, *n*, to the combined pipe, *l*, and at the lower end by the tube, *u*, to a double air-bag, *v* and *x*, which is fitted on the back of the vessel, *a*, and attached to the leather cover, [redacted]

y, at the bottom of the second bag, for the issue of the exhaled air, mixed with any superfluous fresh evaporated air at overpressure. The combined pipe, *l*, consists of strong braided india-rubber tubing, to which a fireman's face-mask, *m*, covering the mouth, nose and eyes, or a miner's mouthpiece, with nose-pinchers, etc., may be screwed on at will. The alarm-clock, *z*, is provided so as to give timely warning that the supply of liquid air is nearing the end.

When carried on the back, in actual work, the apparatus, when fully charged weighing under 25 pounds, affords full use of both arms, and is no encumbrance whatsoever (Figs. 2 and 3).

FIG. 3.—AEROLITH LIQUID-AIR RESCUE-APPARATUS.

When the desired quantity of liquid air has been poured into the nickel vessel (1 quart giving at least ¾ hour's work), 1 gallon equal to 3 hours' work being the maximum capacity of the vessel, pure and deliciously cool air will evaporate and flow to the face-mask. The harder the person works, the more hot air will be exhaled into the diagonal radiator-pipe, and the more fresh air will be vaporised by the increased amount of heat. Consequently, the air-supply is automatically regulated, and increases with the requirements of the wearer. Any surplus vaporised air, which may not be used, will pass downward with the exhaled

air, purifying it at the same time, and will be stored in and distend the double bag, at the back of the apparatus, and will, as soon as the pressure becomes excessive, escape into the open air. The fresh air-supply is ample under all requirements, and the air in the double-bag can always be utilized as a breathable reserve-supply.

The fresh air-supply is absolutely pure, as the always high percentage of oxygen increases with the time that the apparatus is in use. The liquid air contains about 2 parts of oxygen to 1 part of nitrogen. The nitrogen evaporates more quickly than the oxygen, and, consequently, the wearer works under the best possible conditions.

Liquid air can be stored in the vacuum-vessels designed by Sir James Dewar, and will then lose, under ordinary atmospheric conditions, not more than 5 to 10 per cent. by evaporation per day. It can, even at the present moment, where no purely commercial use for liquid air has been universally adopted, be purchased for 5s. per gallon; whereas it can be produced by small plants at 1s. per gallon, and by large plants at 6d., 3d., or even less per gallon. Liquid air can be transported with absolute safety by rail or car. For central rescue-stations or large coal-mines, however, it would certainly be desirable to erect an air-liquefying plant. A plant, requiring about 8 horsepower, producing about 1 gallon of liquid air per hour, and not occupying more than about 45 square feet, can be bought for about £400.

[redacted]

Mr. R. Cremer (Leeds) wrote that as the evaporation of the liquid air, absorbed by the asbestos-wool packing in the aerolith, was caused by the heat from the exhaled air, such evaporation would most likely be not very uniform. Partly water-vapour and carbon dioxide would freeze upon the inner side of the diagonal tube, reducing the sectional area of this tube and possibly blocked this entirely, lessening in any case the uniform exchange of heat, so that less and less air would evaporate from the receptacle during the lengthened use of the apparatus. The produced fresh air (110 to 130 cubic feet per 3 hours, or 0·61 to 0·72 cubic foot per minute) appeared too small, as more than 1·60 cubic feet per minute were needed when the wearer had to carry out heavy work. Therefore a considerable amount of exhaled air would have to be re-inhaled without the carbon dioxide being perfectly eliminated during the short time allowed for cooling between two respirations. A further serious drawback of the aerolith apparatus in practical use was undoubtedly the non-existence of any appliance by which the wearer was warned that the supply of liquid air was nearing exhaustion. After the latter had been evaporated, the frozen carbon dioxide in the exhaling tube would evaporate, and this gas would then be inhaled. For the practical use of apparatus, like that described by Mr. Simonis, a constant large storage of liquid air was absolutely necessary. This stock could not be kept in small Dewar vessels, but would have to be kept in sheet-iron vessels, containing about 11 gallons, fitted with an isolating wool-mantle. The loss, by evaporation, of liquid air in such vessels, containing 11 gallons, amounted to about $\frac{1}{2}$ gallon per hour. The air-liquefying machine, therefore, must be able to supply this loss, and, when the apparatus was in use, it must produce the consumed air, that was $\frac{1}{3}$ gallon per hour. Therefore, the machine would have to produce at least $(\frac{1}{2}+\frac{1}{3}=)$ $\frac{5}{6}$ gallon of liquid air per hour. Further, as liquid air had the property of generating nitrogen only at the beginning of its evaporation, still more air had to be liquefied in order to keep $\frac{5}{6}$ gallon of usable liquid air in stock. The cost of air-liquefying, therefore, amounted, for one rescue-apparatus kept ready for use, to at least $\frac{5}{6}$ gallon or 3d. per hour, or to 2s. 6d. per day of 10 working hours. Ten rescue-appliances would require a liquefying machine with a capacity per hour of about $[\frac{1}{2}+(\frac{1}{3}\times 10)=]$ 4 gallons; and the cost would be (4 gallons at

3d. or) 1s. per hour, or 10s. per day. The cost of a Linde air-liquefying machine, with a capacity of 20 litres or 4·4 gallons per hour, was £1,500. These machines were easily thrown out of order, and it was very probable that a second machine, to be used as a reserve, would be necessary. The wear-and-tear of these machines was considerable, and the annual depreciation should, therefore, be reckoned at 15 to 20 per cent. of the cost-price, that was, for the abovementioned machine, £225 to £300 per year.

He was afraid, owing to the continuous evaporation of the oxygen and the nitrogen from the liquid air in the receptacle, that a concentration of the heavy gases (argon, krypton, xenon, etc.) would occur, and after about one year, the receptacle would not contain 11 gallons of liquid air but almost the same quantity of liquid argon, etc., unfit for breathing; and consequently, the whole amount stored would have to be replaced.

Mr. W. Morton Jackson (Manchester) wrote that liquid air was produced at the works of the British Oxygen Company, Limited, and though he was quite ready to admit that it possessed many characteristics which indicated its peculiar suitability for use in rescue-apparatus, he was of opinion that (1) its extreme volatility at ordinary temperatures and (2) the fact that the oxygen and nitrogen did not evaporate from it in constant proportions, must render its proper control in such apparatus a very difficult matter. He might mention that the Dewar vacuum-vessels were made of glass, and he did not know of any metallic [redacted]

whatever from heat, and there was absolutely no liability of any particles getting into the breathing-tubes. With this apparatus, it was possible to climb over falls, move heavy stones, and crawl through low and narrow places without any distress. With the Vienna type of pneumatogen, however, the heat caused by the chemical action had hitherto been found an inconvenience; but he was informed that a new type was being introduced, which did not possess this fault. He thought that the loss of 5 to 10 per cent. of liquid air per day from evaporation might be some detriment to its employment in rescue-apparatus, and it was possible that the most likely application would be as an auxiliary to some oxygen apparatus; but, until some commercial use was found for liquid air, he was afraid that it would not be likely to supersede oxygen. He asked Mr. Simonis to explain more clearly how the expired air was voided from the apparatus.

Mr. Joseph Dickinson (Pendleton, Manchester) wrote that he had seen previous inventions for the same purpose and witnessed tests, in poisonous gases and under water, intended to show the use of such apparatus for re-entering mines with the ventilation destroyed by explosion or fire; and he had assisted in the mine where bags, containing chemical preparations, were breathed through, but he could not say that on any occasion had he known life to be saved by the use of any such invention. In most of the rescue-operations, the party is composed of true heroes: other persons with distaste for such work, or having important letters to write, or being imperatively wanted elsewhere, being excused. There is risk to those who take part in the work, and in it delay occasionally occurs by an explorer being knocked down, or his head cut by a fall of stone, requiring attention, or it may be his being sent out amid his requests that his name may not be mentioned lest it might alarm his wife or friends. On rare occasions, some delay also occurs by excessive zeal inducing venture into poisonous gas requiring attention; and exceptionally excessive staggering occurs that apparently might be restrained. When thus advancing, time is occupied in bratticing between distant cut-throughs to make up temporarily blown-out air-stoppings, which might be saved if some reliable portable breathing-apparatus were at hand. The use of such apparatus is also apparent when being lowered in a disarranged shaft, and for ex-

ploring in advance of the air-column. One hails, therefore, with satisfaction, the new aerolith with liquid air in a case, without chemicals, valves or complication, the whole weighing 25 pounds—that is, assuming the transition of air from the liquid to the gaseous state to be reliable. It should not be supposed, however, that former inventions for the same purpose are devoid of such usefulness. One great obstacle has been to trust to such apparatus amid such varied surroundings. Even the representing persons, after exhibiting joiner's work in poisonous gas, when protected by the apparatus, have declined the fine advertisement offered of entry into a pit, alleging the risk to be too great. Ordinary explorers may be reliable men, yet they might not think it prudent to isolate themselves among newly-loosened débris, the touch of which is critical, and with a bag on their back weighing 25 pounds, which might be destroyed. Besides this, let them imagine, after passing through irrespirable gas, them coming to a miner stronger than themselves shut in an unbreathable *cul-de-sac* or stocking-end. A drowning man loses consciousness. Those only who have realized how their arms have become pinned and their head submerged by the unconscious person (probably kind and good under ordinary circumstances) know fully what desperation may and does bring about. The rescuer might have to give up his apparatus. Hitherto, the safety-lamp has proved invaluable for testing at the front when re-entering. A reliable breathing-apparatus might assist; but taking in fresh air for all is requisite. Caution is therefore needed in making advances too [redacted]

any great risk was involved in the erection of an apparatus for the production of liquid air, because such a machine could be used at any time, not only for producing liquid air but also for the production of oxygen.

Captain J. A. HAMILTON (Chief Officer of the London Fire Brigade) wrote that experiments had been carried out at headquarters with the following smoke-helmets:—Chapin-Sherman, Draeger, Fleuss-Siebe-Gorman, König, Vajen-Bader and Simonis liquid air. The difficulty in connection with the liquid-air helmet, however, was that if liquid air was not readily obtainable, a special plant had to be installed, which cost about £400. The liquid air evaporated at the rate of about 6 per cent. per day, and it was necessary to have very special containing vessels. The cost of maintenance was about 5s. per week for each helmet. He (Captain Hamilton) had not yet adopted any self-contained helmet in the London Fire Brigade, as the experiments were not completed. The pattern now used by the Brigade was the König helmet, but it was not a self-contained one.

Mr. OTTO SIMONIS (London), replying to the discussion, wrote that he was well conversant with oxygen-appliances; he had himself worked in the Draeger apparatus for 1½ hours, not very long ago, and he was sure that anybody who had used the Draeger apparatus would certainly have been delighted, after about ½ hour's work, if he could have been supplied with air at a lower temperature. He certainly admitted that the Draeger apparatus was almost brought to perfection, so far as regeneration through caustic soda and other chemicals was concerned, but the very use of these was a danger. It might be interesting to Mr. Habershon to know that he (Mr. Simonis) had brought both the Draeger and the Giersberg apparatus to this country in 1903, and that he had despatched one of the first mine-equipments with Draeger apparatus to the colonies.

He certainly agreed with Mr. Joseph Dickinson, who dealt with the subject from a different point of view, that it required a hero at all times to go and do rescue-work. So far as he was personally concerned, he would have no hesitation whatever in going down into a pit with the apparatus to do such work, always provided that he was not going alone. He considered

that it was every man's duty to attempt the rescue of a fellow-creature, who might be in danger; but it was an absolutely undue risk to do so alone.

He was on the most friendly relations with Mr. O. Suess and the Hanseatischen Apparatebau-gesellschaft, and the aerolith apparatus was identical with theirs.

He was pleased to notice that Captain J. A. Hamilton, who was, at the present time, experimenting with a Simonis liquid-air helmet, confirmed the statement that the cost of maintenance was about 5s. per week. The König helmet, referred to by Captain Hamilton, was not a self-feeding helmet, but one to which the air was pumped through a tube.

The storage of liquid air in metal tubes, suggested as a necessity by Mr. Cremer, would be detrimental, and he would strongly advise Mr. Cremer not to remain in the neighbourhood of such a loaded tube, as within a very short time the explosive power of the liquid air would be developed, and the tube would explode with about three times the force of dynamite. There was no reason for not storing liquid air in Dewar vacuum-vessels of 0·44 gallon (2 litres) or 1·10 gallons (5 litres) capacity and certainly he was, as well as everybody else, handling this material very successfully. The percentage of argon, krypton, xenon, etc., in liquid air, referred to by Mr. Cremer, was so small that it was of no practical importance.

The produced quantity of fresh air of 130 cubic feet, or about 0·7 cubic foot per minute, was for all practical purposes an

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12s. Therefore, for every practice of 2 hours, the Simonis apparatus was 9s. cheaper than the Draeger apparatus and 11s. less than the pneumatogen; but this saving was diminished by the loss through evaporation. In a rescue sub-station, requiring 4·4 gallons (20 litres) of liquid air always in store, the loss, when stored in Dewar bottles, would be at the rate of 5 per cent. per day, or 0·22 gallon (1 litre) or 3d. per day, or £4 11s. 3d. per annum. Therefore, this sub-station required, for replacement, 1·1 gallons (5 litres) of liquid air every fifth day. The standard number of pactices in Austria and Germany was four times per week, and this necessitated, including evaporation, a supply of, say, 0·88 gallon (4 litres) per week-day. Consequently, a liquefying plant, with a capacity of 1·1 gallons (5 litres) per hour, working 60 hours weekly, would suffice to supply twelve rescue sub-stations; and it would cost, including the expense of erection, say, from £500 to £600.

Four practices per week, at twelve sub-stations, implied 2,500 practices per annum, and the saving of the Simonis against the Draeger appliance, at 9s. per practice, amounted to £1,125, and against the pneumatogen apparatus to £1,375. If, in this country, the number of practices were reduced to the absolute minimum of one per week at every sub-station, or 600 per annum, there would be a yearly over-production of about 1,760 gallons (8,000 litres) of liquid air from the plant for re-sale, and there would be a saving against the Draeger of £270, and against the pneumatogen of £330. From these savings the loss from evaporation of £4 11s. 3d. per sub-station, or, say, £55 must be deducted; and the net saving would be £215 or £275 respectively. The 1,760 gallons (8,000 litres) of over-produced liquid air might be sold to iron-works or blast-furnaces at, say, only 2s. 4d. per gallon, or a profit of 1s. 2d. per gallon (6d. per litre, or a profit of 3d. per litre), or £100 per annum. In addition, the liquid-air plant would, at the same time, have produced compressed oxygen, which was marketable everywhere nowadays. Consequently, at a central rescue-station in a mining district, with sub-stations at the various pits, a liquid-air rescue-installation would, through the profit on the surplus liquid air and through savings, as compared with other rescue-systems, even calculated under the most unfavourable assumption of only one practice per week, very nearly balance its own cost.

He thought that he had clearly shewn that the Simonis apparatus had not only far-reaching advantages for its wearer, but that it had also the great advantage of being more economical than any other system. As soon as the use of liquid air for commercial purposes had become more general, a central rescue-station, with spare plant, would be able to sell such quantities of liquid air as would give a satisfactory return on the cost of erection and maintenance of the plant for rescue-work.

Dr. J. Adamson (Hetton-le-Hole) wrote that Mr. Simonis' paper was very interesting, and, as the subject was comparatively new to him, he felt that he was not at present competent to make any remarks. He was strongly of opinion, however, that the members of the St. John Ambulance Brigade, trained as they were to act in unison and to obey at once any orders given, were eminently fitted to carry out the use of rescue-apparatus at mines.

Mr. Stuart C. Wardell (Alfreton) wrote that, in his opinion, a liquid-air rescue-appliance was not of much use except for exploring main roads that were free from falls and obstructions, and that it would not be of much help where roads were nearly closed with only room to crawl over. Members of the St. John Ambulance Brigade would be glad of any instruction that had for its object the saving of life, and they would gladly avail themselves of any training in the use of rescue-appliances, but [redacted]

it was hoped that they would always be able to call on a reliable body of men to send anywhere, as well as to test various appliances that might be invented.

Mr. R. RICHARDSON (Barrow collieries) wrote that members of the St. John Ambulance Brigade, employed at individual collieries, could most suitably be trained in the use of rescue-appliances. These appliances must be available quickly in case of accident, and, consequently, must be worked by men employed at the colliery; further, there must be enough trained men at each colliery to relieve one another from time to time. A head official must not lead an exploring party, as his services would be required in other directions after a serious explosion. He did not think that rescue-appliances would enable those wearing them to perform quite what most people expected, as they were cumbersome things at best; and, after an explosion, in his experience, the roads which had to be travelled were usually in such a condition as not to admit of anything of a larger size than the body of a man to get through with safety. Rescue-appliances would be useful in conjunction with an ordinary exploring party, to go a little in advance and to repair stoppings temporarily, so as to restore the ventilation. They would also be useful in the case of a man being prostrated by dangerous gases in a place, and, if they could be got there quickly enough, no doubt he would be rescued; but, under ordinary conditions, in his opinion, too much was expected from their use.

In Yorkshire, there are central stations supported by three or four collieries, where, say, six men are sent at a time so that they may be thoroughly trained; and arrangements are being made so that, in addition to these men, each colliery will employ a man thoroughly acquainted with the appliances. These may then be kept at each colliery for use in case of accident, and this man would ensure that they were absolutely in perfect working order before any person was sent into the mine.

Mr. ARTHUR ELLIS (Wigan) wrote that, in April last, a committee was appointed by the Lancashire and Cheshire Coal Association to consider the advisability of forming a rescue-brigade and station in connection with the association, and many meetings had been held since that date to discuss the question from all points of view. The members of the committee had

visited rescue-stations that had been already established at Tankersley and Normanton, and had an opportunity of seeing various forms of apparatus in use. It would appear that it was quite practicable to train miners in the use of the apparatus, although a considerable amount of training might be necessary, as the apparatus in the hands of an untrained man was worse than useless. The idea of the committee was that an experimental gallery should be built in connection with the central station, capable of being charged with a noxious atmosphere, and made to represent, as far as possible, the conditions that would be encountered in a travelling-road underground after an explosion. The workmen from the various collieries would attend the station periodically for courses of instruction, and, after they had become accustomed to wearing and carrying the apparatus, they were to be exercised in the experimental gallery in a noxious atmosphere for short periods. It was hoped in this way that a considerable number of men, from each of the collieries taking part in the scheme, would become accustomed to the use of the apparatus, and be able to work whilst wearing it. The class of men who were to be trained were ordinary colliers, but he believed that preference would be given to members of the different ambulance-classes, and it was not anticipated that there would be any difficulty in instructing intelligent men in the use of the apparatus. Although he (Mr. Ellis) had had no practical experience in the matter, he thought, from what he had heard, that there would be no difficulty in the way of training such men as belonged to the [redacted]

In regard to the nature of the apparatus to be used, it was difficult to speak with any degree of confidence, as, apparently, there were several kinds of apparatus, none of which appeared to be absolutely perfect as yet. In one class of helmet, with a glass front, the wearer's mouth was free, and the wearer was able to speak and be heard to a certain extent; while, in another class, the mouth-piece was held in the mouth and the wearer could not speak. It had been suggested that a rescue-party should consist of four or five men, the leader of the party wearing a glass-faced smoke-helmet, and it would be his duty to give directions and instructions while the work was in progress; while the other members of the party, who were to be the workers, would wear the other class of apparatus.

Mr. Claude B. Palmer (Pelaw-on-Tyne) wrote that the training of workmen at collieries to assist in rescue-work, and to be of assistance for the proper use of the various rescue-appliances, was an important subject. The men, in the first place, should be holders of first-aid certificates of the St. John Ambulance Association and thoroughly efficient in ambulance-work. This could only be obtained by constant practice, which was not possible under the system of attending classes in first-aid during a course of five or six lectures; and the mere fact of men passing examinations in first-aid was not sufficient to make them thoroughly efficient.

The branch of the Association, known as the St. John Ambulance Brigade, met all requirements to train ambulance-men thoroughly, as the rules of the brigade, to ensure efficiency, included provisions that the members must each be re-examined in first aid annually and attend a minimum of twelve drills or practices each year; and they also were required to be present at an annual inspection, when their efficiency was tested in drill and in the use of the stretcher.

The St. John Ambulance Brigade was formed for the purpose of carrying on the work begun by the Association in teaching first-aid students to be thoroughly efficient; and, at many collieries, there were now divisions and corps of the St. John Ambulance Brigade who were competent to take over the work of rescue-stations, and to be thoroughly trained in their use. The members of the brigade, being drilled, were accustomed to dis-

cipline, and well organized under officers who knew them and who could rely on them for any emergency. The system of having drills throughout the year, at which there was practice in first aid, rendered the men always efficient, as was required by the brigade-orders.

At those collieries where there were divisions of the brigade, the men took the greatest interest in the work, and there was a great competition amongst themselves to be efficient. There would consequently be little difficulty in extending their work to the handling of the various appliances used for rescue-work. Unless the workmen were thoroughly drilled in the manipulation of these appliances, there was a great danger that such appliances would not only be useless when most required, but they might be the means of a rescue-party losing their own lives. There should be constant practice in the use of the rescue-appliance, and the men must be accustomed to act under recognized leaders. These practices should be held occasionally down the pit, and when possible the parties should explore into old and disused workings so as to get accustomed to travel in rough ground and over falls.

The PRESIDENT (Mr. J. H. Merivale) moved a vote of thanks to Mr. Simonis for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

SINKING THROUGH MAGNESIAN LIMESTONE AND YELLOW SAND BY THE FREEZING-PROCESS AT DAWDON COLLIERY, NEAR SEAHAM HARBOUR, COUNTY DURHAM.

By E. SEYMOUR WOOD, M.Inst.C.E., F.G.S.

I.—Introduction.

Dawdon colliery (Fig. 32), situated on the north-east coast, about a mile south of Seaham Harbour, will work the under-sea coal-royalty, leased by the Marquis of Londonderry from the Crown.

Fig. 32.—Dawdon Colliery.

II.—Geology.

The shafts are sunk on the eastern land-limit of the Durham coal-field. The Coal-measures crop out at the surface on the western side of the coal-field and dip towards the coast-line, where they are covered by Permian rocks, consisting of Magnesian Limestone, Marl Slates and Yellow Sand. The map (Fig. 1, Plate XXVII.) shows the area of the Permian rocks. The first section

(Fig. 2, Plate XXVII.) is taken from Harton colliery in the north to Castle Eden colliery in the south, the second section (Fig. 3, Plate XXVII.) from Moorsley colliery in the west to Dawdon colliery in the east, and they show the thicknesses of the Permian rocks as proved in the shafts of the neighbouring collieries.*

The difficulties in sinking shafts in this district arise from the occurrence of the Magnesian Limestone and the underlying Yellow Sand, the latter being usually found as a quicksand. Both of these strata contain large quantities of water.

Very difficult sinkings through this ground were experienced at the adjoining collieries of Haswell, Horden, Murton, Ryhope, Seaham, Seaton and South Hetton, all of which were sunk by the open-pit pumping process. In the sinking of the shafts at Marsden colliery, insurmountable difficulties were experienced with the pumping-plant system, and the shafts were finally sunk by the Kind-Chaudron system.

At Dawdon, the Coal-measures are overlain by the following thicknesses of strata:—Soil, 1 foot; boulder-clay, 5 feet 6 inches; old beach-gravel, 4 feet 6 inches; and Permian rocks, comprizing Magnesian Limestone, 356 feet 10½ inches; Marl Slates, 3 feet 1½ inches; and Yellow Sand, 92 feet 4 inches (Table III.).

The Magnesian Limestone, 356 feet 10½ inches thick, was, as usual, full of gullets giving off large quantities of water. Some

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grey sand, 75 feet; brown-grey sand, 17 feet 4 inches; and below the last-named lies grey stone, 1 foot thick.

The Coal-measures were found at the depth of 464 feet 4 inches.

III.—Sinking of Shafts with Pumping Machinery.

The first sod of the Theresa shaft was cut by the Marchioness of Londonderry, and the first sod of the Castlereagh shaft by Viscount Castlereagh on August 26th, 1899; and sinking was commenced on March 19th, 1900.

Theresa Shaft.—The Theresa shaft, 20 feet in diameter, was sunk to a depth of 350 feet by means of pumps, and lined with 225 feet of cast-iron tubbing and 96 feet of brick-walling.

The plant in the shaft comprized two pumping sets, 24 inches in diameter; one pumping set, 25 inches in diameter; and two Evans vertical sinking pumps, with steam-cylinders, 24 inches in diameter, and ram-plungers, 16 inches in diameter and 24 inches stroke, jointly capable of dealing with 7,000 gallons of water per minute. The water was pumped to the level of a drift, 90 feet below the surface, through which it ran to the sea-beach.

The largest feeder was 6,075 gallons per minute (Table VI.).

At a depth of 349 feet 6 inches, a drift was driven from this shaft to the Castlereagh shaft, to take the water from that shaft. The water was run down a bore-hole lined wih steel tubes, 9½ inches in diameter (Fig. 4, Plate XXVII.).

From the bottom of the shaft, three bore-holes were put down to test the thickness of the sand. It was found at a depth of 19 feet below the pit-bottom, and estimated at 84 feet thick.

The sinking operations in this shaft were stopped on May 17th, 1902, to allow the Castlereagh shaft to reach the same depth, and in order that both shafts might be sunk simultaneously through the sand.

Castlereagh Shaft.—The Castlereagh shaft, 20 feet in diameter, was sunk to a depth of 204 feet, and lined with 88 feet of cast-iron tubbing and 96 feet of brick-walling.

The water from this pit was run off by the bore-hole to the Theresa shaft (Fig. 4, Plate XXVII.). Two Evans pumps, similar to those in the other shaft, pumped any excess of water which did not drain through the bore-hole.

At a depth of 200 feet, the feeder of water was 5,750 gallons per minute, and, together with 1,300 gallons per minute flowing into the bottom of the Theresa shaft and drift, the total quantity of water being pumped was 7,050 gallons per minute (Table IV.).

The pumping of such a feeder of water before reaching the Yellow Sand, and the probability that the feeders would be greatly augmented in sinking through the sand-bed, led to the consideration of the question whether it would be desirable to erect additional pumping plant or to carry out the sinking of the shafts through the sand-bed in a frozen state. On serious deliberation, it was decided, after a conference with Mr. J. B. Simpson,

so long as should be necessary for the purpose of sinking the shafts and of renewing or of completing the existing or any further tubbing of the same.

The freezing process may be divided into four stages:—(1) The boring of the holes to receive the freezing-tubes and the insertion of the freezing-tubes; (2) the freezing of the strata, or the making and the maintaining of the ice-wall; (3) sinking within the ice-wall, and inserting all necessary tubbing; and (4) thawing the ice-wall and extracting the freezing-tubes.

FIG. 34.—EAST SIDE OF SINKING-SHEDS AND FREEZING-HOUSE.

(a).—Boring the Holes.

Previous to the boring of the holes to receive the freezing-tubes, a fore-shaft, *c*, 36 feet in diameter, was formed round each shaft, sunk to a depth of 8 feet and brick-lined, *d*, to the surface (Fig. 5, Plate XXVII.). Boring was started at this level, the holes being placed equidistant round a circle 30 feet in diameter (Figs. 6 and 7, Plate XXVIII.). The purposes of the fore-shaft (Fig. 5, Plate XXVII.) are as follows:—(1) To fix securely a tube, *e*, perfectly vertical, to act as a guide-pipe, the object being to keep the bore-holes as vertical as ever possible; and (2) to have a convenient chamber, *c*, in which all connections between the collectors and freezing-pipes, *f* and *g*, can be made, and from which each individual freezing-tube can be controlled;

and to take observations of the temperatures and watch the circulation of the brine in the freezing-tubes.

Castlereagh Shaft.—Boring was commenced at the Castlereagh shaft on May 20th, 1903, with three boring-machines, each driven by a vertical engine. Three small Worthington pumps were used for pumping water into the bore-holes, and two steam-winches for lifting and lowering the rods and tubes.

Twenty-eight bore-holes were marked off on a circle 30 feet in diameter surrounding the shaft (Fig. 6, Plate XXVIII.). Trouble was met with at Nos. 7 and 8 holes, necessitating the boring of extra holes, Nos. 7*a* and 8*a*, the whole being completed by April 7th, 1904. The depth of each of the holes was 484 feet. The average time occupied in boring each hole was 24 days (Table I.)

TABLE I.—TIME OCCUPIED IN BORING THE HOLES TO RECEIVE THE FREEZING-TUBES AT THE CASTLEREAGH SHAFT.

No. of Bore-hole.	Boring		Time.	No. of Bore-hole.	Boring		Time.
	Commenced.	Finished.			Commenced.	Finished.	
			Days.				Days.
1	1903, May 20	1903, June 10	21	15	1903, July 26	1903, Aug. 14	20
2	,, Oct. 14	,, Nov. 6	23	16	,, July 2	,, July 25	24
3	1904, Jan. 10	1904, Jan. 28	18	17	,, May 29	,, July 1	33
4	1903, Dec. 1	,, Jan. 6	37	18	,, Nov. 3	,, Nov. 27	24
5	,, Sept. 8	1903, Oct. 9	32	19	,, Sept. 9	,, Oct. 7	28
6	,, July 30	,, Aug. 30	31	20	,, Nov. 28	,, Dec. 23	26
7	,, July 8	,, July 28	21	21	1904, Jan. 6	1904, Feb. 7	23
7*a*	1904, Mar. 23	1904, April 7	15	22	1903, Dec. 24	,, Jan. 17	24
8	1903, June 12	1903, July 6	25	23	,, Nov. 8	1903, Dec. 3	26

[redacted]

The average time occupied in boring each hole to a depth of 484 feet was 24 days (Table II.) The quantity of water used for boring was about 11,000 gallons per hour.

TABLE II.—TIME OCCUPIED IN BORING THE HOLES TO RECEIVE THE FREEZING-TUBES AT THE THERESA SHAFT.

No. of Bore-hole.	Boring Commenced.	Boring Finished.	Time.	No. of Bore-hole.	Boring Commenced.	Boring Finished.	Time.
			Days.				Days.
1	1903, June 23	1903, July 16	24	15	1903, Oct. 12	1903, Oct. 30	18
2	,, July 17	,, Aug. 6	21	16	,, Nov. 16	,, Dec. 3	18
3	,, Aug. 8	,, Aug. 28	20	17	,, Dec. 12	1904, Feb. 5	41
4	,, Sept. 1	,, Sept. 23	22	18	1904, Feb. 16	,, Mar. 9	22
5	1904, Feb. 7	1904, Feb. 24	18	19	,, Mar. 9	,, Apr. 22	39
6	,, Jan. 5	,, Jan. 24	19	20	1903, Nov. 4	1903, Nov. 24	20
7	1903, Nov. 30	1903, Dec. 19	20	21	,, Aug. 4	,, Aug. 31	27
8	,, Oct. 28	,, Nov. 21	24	22	,, Oct. 9	,, Oct. 27	18
9	,, Sept. 27	,, Oct. 20	23	23	,, Dec. 21	1904, Mar. 3	31
10	,, Aug. 30	,, Sept. 17	19	24	1904, Mar. 3	,, Mar. 25	22
11	,, July 13	1904, April 6	37	25	,, Jan. 28	,, Feb. 20	24
12	,, June 23	1903, July 12	20	26	1903, Nov. 23	1903, Dec. 13	20
13	,, July 28	,, Aug. 16	20	27	,, Oct. 21	,, Nov. 10	21
14	,, Aug. 18	,, Oct. 3	20	28	,, Sept. 8	,, Oct. 9	32
14a	,, Dec. 9	,, Dec. 20	11				
14b	,, Dec. 22	1904, Jan. 18	28		Average time ...	...	24

All bore-rods and chisels were made of steel, with a hole passing down the centre for the circulation of water to wash out the borings.

All the holes were bored to a depth of about 130 feet with a chisel, 9⅝ inches in diameter, and then lined with tubes, 9½ inches in diameter. From that point, the holes were bored with a chisel 8 inches in diameter, inner tubes, 7½ inches in diameter, being put down from the surface. The holes were carried down to a depth of 460 feet, entering into the Coal-measures, where the sand was cut off in most of the holes. The remaining depth of 24 feet was bored with a chisel, 6½ inches in diameter. When the full depth was attained, a lining of tubes, 6¼ inches in diameter, was placed inside the whole length of each bore-hole. This lining was necessary to secure the whole depth of the hole, to keep it clean, and to act as a guide when introducing the freezing-tubes.

(*b*).—*Plumbing the Bore-holes.*

The plumbing of the holes was done from a scaffold, *h*, 29 feet above the bore-holes. The plumb, connected by a wire, *i*, passing

over a small pulley, *j*, to a drum, *k*, was set to the centre of the hole, lowered down in 33 feet lengths, and the deviation measured and calculated (Fig. 5, Plate XXVII.). This system of plumbing was proved to be absolutely unreliable (Figs. 6 and 7, Plate XXVIII., showing the deviation of the bore-holes). A more perfect system of surveying and finding the exact position or deviation of a bore-hole for this purpose could be advantageously employed.

It is most important that the bore-holes should be as nearly vertical as ever possible. This was overcome to some extent at Dawdon by the use of a strong vertical pipe, *e*, in the fore-shaft, as a guide, and by using very strong lining tubes. If the hole becomes much out of plumb, these lining tubes gradually work themselves fast, and cannot be turned or twisted round in the hole.

(*c*).—*Freezing-tubes.*

The freezing-tubes (Fig. 8, Plate XXVIII.) comprize:—(1) An outer tube, *a*, 5 inches in diameter, in lengths of 16 feet; they are inserted to the whole depth of the bore-hole, and the bottom end is closed. (2) An inner tube, *b*, 2½ inches in diameter, reaching to within 33 feet of the bottom of the tubbing at each shaft, where a special double nipple, *c*, with an inside thread, was placed, making a connection with the outer tube. The air-space, *d*, formed between the outer tube, *a*, and the inner tube, *b*, down to this point acts as an isolating chamber, and prevents any direct connection with the strata, thus protecting the tubbing from severe frost. An expansion-joint, *e*, was placed midway be-

[redacted]

engines of 135 horsepower, driving four ammonia-compressors (Figs. 9 and 10, Plate XXVIII, and Figs. 35 and 36). One steam-engine, A, with a cylinder 19¾ inches in diameter and 31½ inches stroke, and fitted with Rider expansion-gear, ran at 72 revolutions per minute. The other steam-engine, B, with a cylinder, 19¾ inches in diameter and 19¾ inches stroke, and fitted with Meyer expansion-gear, ran at 120 revolutions per minute. The steam had a pressure of 100 pounds per square inch. Both of these engines transmitted their power by belting to a shaft, C, by which two compressors, F and G, were driven. Two compressors, D and

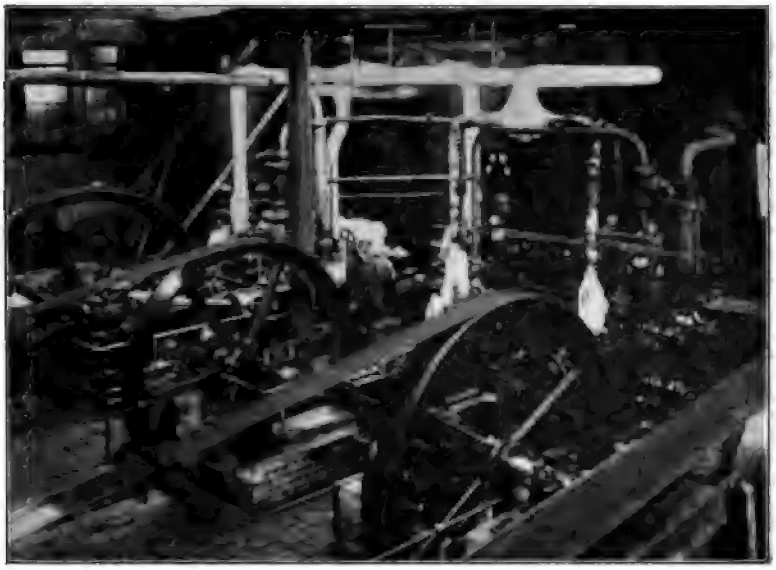

FIG. 35.—FREEZING-PLANT.

E, were coupled direct to one steam-engine, A. The ammonia-compressors were of the following dimensions:—D, one cylinder, 13 inches in diameter and 24 inches stroke; E, one cylinder, 11 inches in diameter and 31½ inches stroke; F, one cylinder, 10 inches in diameter and 20 inches stroke; and G, one cylinder, 10 inches in diameter and 20 inches stroke. All the ammonia-compressors were double-acting, with two cylindrical suction-valves on the right side and two pressure valves on the left side.

The freezing system is the same as in all ammonia-plants (Fig. 11, Plate XXVIII.). The ammonia, at a pressure of 150

pounds per square inch, was circulated through the spiral pipes, *b*, in five cooling-condensers, *c*, and liquefied by the extraction of heat, effected by circulating through the condensers (Fig. 37) 14,000 gallons of cooling water per hour. The liquid ammonia passed to four refrigerating-tanks, *d*, containing 20,000 gallons of brine, expanded through an expansion-valve, *e*, and circulated through 2,000 feet of spiral tubing, *f*, in each tank, reducing the temperature of the brine to $-17°$ Cent. (1·4° Fahr.), and was then conveyed to the compressors, *a*, to be compressed again to 150 pounds per square inch. The first charge of liquid ammonia placed in the compressors weighed 16 cwts.

The cooling water for use in the condensers was pumped from the sea, and its temperature varied from 5° to 18° Cent. (41° to 64° Fahr.), according to the season of the year (Fig. 12, Plate XXIX.).

The brine, a [redacted]

Castlereagh Shaft.—The freezing plant was connected to the Castlereagh shaft on April 22nd, 1904, 18 holes being put into circulation, and the remaining 11 holes were put into circulation on the following day.

The temperature of the brine going to the pit was −13·5° Cent. (7·7° Fahr.) and on returning it was −6° Cent. (21·2° Fahr.). The temperature of the brine on the closing of the ice-wall and at the commencement of the sinking of the shaft on November 7th, 1904, was −17° Cent. (1·4° Fahr.) and on returning it was −13° Cent. (8·6° Fahr.).

On June 9th, 1904, careful measurements were made, showing the position of the water in the shaft, and it was found

FIG. 37.—SPIRAL TUBES FOR COOLING-CONDENSERS AND REFRIGERATION-TANKS.

that the water-level was influenced by the height of the sea-tides (Fig. 13, Plate XXX.). The water-level varied from 13½ to 23½ inches and was felt in the shaft 2 to 4 hours after high water and low water at Seaham Harbour.

It was decided to fill the bottom of the shaft with concrete, so as to stop the rise and fall of water in the shaft, with its accompanying displacement of water, which might delay the formation of the ice-wall. From July 20th to 22nd, 1904, 190

tons of concrete were put down the shaft, filling the space above the level of the bottom crib of tubbing, and this stopped the water flow (Fig. 14, Plate XXX.). There was no further variation of water-level in the shaft until the ice-wall closed, when a rise of about ½ inch per day was recorded (Fig. 15, Plate XXX.).

The temperature of the water in the shaft, when freezing commenced, was 9° Cent. (48·2° Fahr.), and it decreased to −0·5° Cent. (31·1° Fahr.) at the bottom and 1° Cent. (33·8° Fahr.) at the top of the shaft, during the formation of the ice-wall.

On October 12th, 1904, when the water was drawn out of the shaft, it was found that ice had formed on the tubbing for about 40 feet above the concrete; it was thin at the top, thickening towards the bottom to about 3 feet thick on the concrete and round the sides of the tubbing.

Sinking was then commenced in this shaft.

The following difficulties with the freezing-tubes were encountered:—On October 31st, 1904, the brine in No. 15 hole was found to be circulating indifferently; the central tubes were taken out, and they were found to be broken off below the expansion-piece in the freezing-tube at a depth of about 320 feet. Repeated attempts were made to draw the broken length; and eventually some of the drawing instruments were broken off and lost in the hole. On April 9th, 1905, a freezing-tube, 3 inches in diameter, with a closed end and a central tube, were placed within the old freezing-tube, as far as the hole was open; and circulation was maintained by this means from that date. This

3 inches in diameter, was continued through the Magnesian Limestone and Yellow Sand, in the ice-wall, down to the Coal-measures. On the completion of this hole, it was found that the freezing-tube, 3 inches in diameter, could not be made to pass through the hole drilled in the old freezing-tube. On June 19th, 1905, when sinking through the drift between the Castlereagh and the Theresa shafts, on a level with the obstruction in No. 16 freezing-tube, a hole was cut back in the Magnesian Limestone near the drift and the tube, *b*, was exposed (Fig. 6, Plate XXVIII). It was then found that the freezing-tube had deviated from the vertical at the expansion-joint, and that the tube underneath that joint had been bored through. The expanding piece and part of the tube beneath were cut out (Fig. 38), a fresh hole was bored from that point in the ice-wall to a depth of 460 feet, lined with freezing tubes, 3 inches in diameter, from the surface, connected to the collectors, and circulation was maintained in it until the end of the freezing.

The length of time required to form the ice-wall in this pit was 185 days. The ice-wall was maintained for 353 days; the brine was cut off from the shaft on October 19th, 1905; the total time of freezing at this shaft being 538 days.

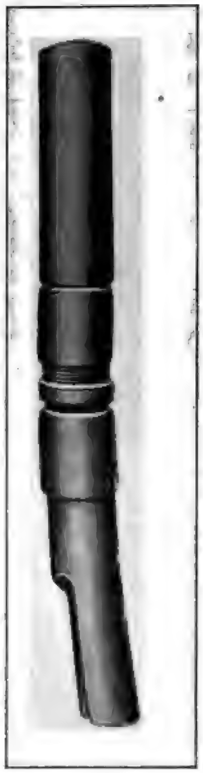

FIG. 38.—NO. 16 FREEZING-TUBE.

Theresa Shaft.—The freezing plant was connected to the Theresa shaft on June 10th, 1904, three holes being put in circulation, and on July 18th, the whole of the freezing-tubes were put in circulation. The temperature of the brine going to the pit was $-13°$ Cent. ($8{\cdot}6°$ Fahr.) and on returning $-8{\cdot}5°$ Cent. ($16{\cdot}7°$ Fahr.).

The water-level in this shaft was also affected by high tides and low tides at sea, the displacement being almost the same as at the Castlereagh shaft (Fig. 16, Plate XXX.). The water in this pit was tested by taking samples; it was found to contain 7 per cent. of salt at the bottom of the pit and 3 per cent. at

water-level; and, after the water had been pumped out of this pit for two days, it was found to remain uniform at 3 per cent. throughout the shaft.

On August 31st, 1904, the bottom of the shaft was filled with débris, A, to above the level of the bottom crib of tubbing (Fig. 17, Plate XXXI.). After allowing time for it to settle, 90 tons of concrete, B, were deposited, on September 8th, 1904, on the top of the rubbish so as to stop the rise and fall of water, as influenced by the tides.

On November 1st, 1904, 15 feet of water was drawn out of the shaft to test whether the ice-wall was formed, but the level of the water gradually rose up to November 7th, when a further depth of 35 feet of water was drawn out (Fig. 18, Plate XXXI.); and from this depth, the water commenced to rise very rapidly till it reached water-level. The rise and fall of the water-level again proved that the ice-wall was not formed; and on November 21st, 1904, 14 tons of concrete, C, were put down the shaft (Fig. 17, Plate XXXI.). As the rise and fall of water still continued, on November 30th, 1904, 25 tons of concrete, D, were put down the shaft, and the rise and fall of the water then ceased (Fig. 18, Plate XXXI.).

On January 18th, 1905, another attempt was made to test the ice-wall at this shaft, and the water was drawn out to a depth of 27 feet 4½ inches. The water-level, thereafter, gradually rose, until on January 28th, 1905, it had risen 3 feet [redacted]

drawn out, and careful observations were taken of the ice-deposit on the sides of the tubbing as the water-level was lowered. A bare place, *ab* (that is a portion of the tubbing not covered with ice), was found to run for some considerable depth on the west side of the shaft at the position of No. 22 bore-hole (Figs. 22 and 23, Plate XXXII.). On reaching a depth of 132 feet, a feeder of 1,000 gallons per minute, issuing from the bottom of the shaft, proved conclusively that the ice-wall had not been formed.

The shaft was filled as quickly as possible with water by diverting the overflow from the cooling tanks, so as to minimize, as far as possible, the breach in the ice-wall. It was then found that the water-level was again influenced by the tides. Fig. 19 (Plate XXXI.) records the variations of the level of the water from January 15th up to and including March 4th, 1905. On February 27th, 1905, 90 tons of concrete, E, were put into the shaft, and the rise and fall of water was stopped (Fig. 17, Plate XXXI.).

From the diagram (Fig. 29, Plate XXXIII.) showing the temperatures of the brine going down the central tube and returning to the surface, the loss of temperature in the strata at each hole, and from observations of the ice-deposit exposed on the sides of the tubbing on February 21st, 1905, it was thought that the breach in the ice-wall was in the vicinity of No. 22 hole on the west side of the shaft. To strengthen the ice-wall at this point, it was decided to put down a new bore-hole, *a*, adjacent to No. 22 hole, in the ice-wall, and to fit it with freezing-tubes (Fig. 7, Plate XXVIII.). On May 27th, 1905, this hole was commenced; but the frost was so severe in the ice-wall that, despite every precaution, the rods, chisels, etc., were many times frozen fast in the hole and it had to be overbored. This hole was eventually abandoned at a depth of 284 feet, on August 12th, 1905.

On August 10th, 1905, the shaft was again tested, and all the water was drawn out. It was found that the ice-wall had formed, the bottom of the shaft showed a mass of ice, 3 feet 6 inches thick all round the tubbing (Figs. 20 and 21, Plate XXXII.). This diagram shows clearly the action of the double nipple and isolation-chamber, *c*, as the thickness of the ice increases, where the freezing-tubes come into direct contact with the strata, and decreases where the isolation-chamber comes into effect.

On clearing away the ice in the bottom of the shaft, sinking was commenced on August 14th, 1905. The temperature of the brine going to the shaft was −19° Cent. (−2·2° Fahr.), and it was returning at a temperature of −16° Cent. (3·2° Fahr.).

The temperature of the water in this shaft at the commencement of the freezing was 11° Cent. (51·8° Fahr.), and it decreased to 0·5° Cent. (32·9° Fahr.) on the formation of the ice-wall.

The circulation of brine to this shaft was cut off on February 16th, 1906. The total time of freezing and maintaining the ice-wall was as follows:—Forming the ice-wall, 392 days; maintaining the ice-wall, while sinking, etc., 186 days; the total time of freezing being 578 days. The length of time taken to freeze this shaft was increased by drawing out the water from the shaft before the ice-wall was sufficiently strong to stand the pressure put on it.

(e).—Sinking in the Frozen Ground.

Through the limestone, naturally hard but with its hardness intensified by the frost, explosives were used to blast out the rock. Great care was required in placing the shot-holes and regulating the quantity of explosive used, to prevent any breakage of the freezing-tubes surrounding the shaft and so cause a leakage of brine, which might damage the ice-wall. The following shot-firing regulations were adopted:—

A. Black compressed powder must be used for all shots.

B. Sumping holes must not be more than 50 inches deep. Not more than [redacted]

that holes on the side had to be drilled by rock-drilling machines and the stone removed by stub and feather. Little Jap hand pneumatic rock-drilling machines were also used for this work and gave very good results in dry ground. To protect the sinkers' hands from frost-bite and their eyes from being cut by sharp pieces of rock and sand from pick and drill-rod points, leather gloves and gauze-goggles were provided.

Castlereagh Shaft.—After all the water had been drawn out of the Castlereagh shaft, sinking was commenced on October 17th, 1905. All ice and soft concrete were removed from the bottom. Eight holes were drilled in the concrete, through specially prepared stuffing-boxes that could be shut, should there be any inrush of water up the holes (Fig. 26, Plate XXXII.) to

TABLE III.—SECTION OF STRATA SUNK THROUGH IN THE CASTLEREAGH SHAFT, DAWDON COLLIERY.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
	Alluvium—				
1	Soil	1	0	1	0
2	Clay	5	6	6	6
3	Gravel	4	6	11	0
	Magnesian Limestone—				
4	Strong marl, with limestone-girdles	50	10	61	10
5	Limestone, with strong marl-partings	32	7	94	5
6	Marl, with gullets	84	7	179	0
7	Hard grey limestone	34	6	213	6
8	Yellow limestone, with red marl ...	13	2	226	8
9	Hard grey limestone	65	7	292	3
10	Grey and yellow limestone ...	17	6	309	9
11	Yellow limestone...	22	0	331	9
12	Hard grey limestone	5	6	337	3
13	Hard grey limestone, in panels	30	7½	367	10½
	Marl Slate— Ft. Ins.				
14	Soft shale ... 0 1¼				
15	Hard shale... 1 11¾				
	———	2	1	369	11½
16	Fish-bed	1	0½	371	0
	Yellow Sand—				
17	Blue-grey sand ...	75	0	446	0
18	Brown-grey sand ...	17	4	463	4
	Coal-measures—				
19	Very hard grey post-girdle ...	1	0	464	4
20	Dark-grey shale, with red shale-bands	21	0	485	4
21	COAL	0	3	485	7
22	Grey shale	2	5	488	0
23	COAL	4	4½	492	4½
24	Grey post	2	2½	494	7
25	Seggar-clay ...	11	8	506	3
26	COAL	0	10	507	1
27	Grey shale	5	9	512	10
28	Dark-grey shale ...	2	10	515	8
29	COAL	0	1¾	515	9¾
30	Dark-grey shale ...	0	10¼	516	8
31	Grey post, with shale panels ...	9	9	526	5
32	Very hard grey post	1	1	527	6
33	Grey post, with shale partings ...	12	0	539	6
34	Dark-grey shale ...	0	9	540	3
35	Grey shale	0	4	540	7
36	Post-girdle ...	0	2	540	9
37	Grey shale	0	3	541	0
	Ft. Ins.				
38	COAL ... 1 5				
39	Stone .. 0 1½				
40	COAL ... 1 10½				
	———	3	5	544	5
41	Seggar-clay ...	4	5	548	10
42	Grey shale	3	3	552	1
43	COAL	0	7	552	8
44	Seggar-clay ...	10	10	563	6

ascertain whether the strata below the concrete were frozen. These holes were put down about 4 feet into the rock. Subsequently, two holes were put down to a depth of 15 feet into the rock. The whole of the concrete was then removed, and sinking was commenced in the frozen strata at a depth of 203 feet 2 inches in the Magnesian Limestone, on October 31st, 1905 (Table III.).

At this depth, the ice-wall was not frozen solid across the shaft, there being an unfrozen core in the centre. Diagrams (Figs. 27 and 28, Plate XXXII.) were taken to show the ice-ring inside the shaft on December 9th, 1905, and January 8th, 1906. A fortnight later the whole of the shaft-bottom was frozen solid.

As is usual in Magnesian Limestone, large gullets were found; and as these were invariably filled with ice, they showed the previous presence of large quantities of water.

The progress of the sinking through the Magnesian Limestone was slow, owing to the shot-firing restrictions. The average progress in rock was 5½ feet per week, and including sinking, and tubbing and wedging, etc., it was 4½ feet per week. In the Yellow Sand, the progress was 20 feet 10 inches per week, and including sinking, and tubbing and wedging, etc., it was 7½ feet per week.

TABLE IV.—ACCOUNT OF THE CAST-IRON WEDGING-CRIBS IN THE CASTLEREAGH SHAFT, DAWDON COLLIERY.

No. of Crib.	Description of Strata forming the Bed of the Crib.	Depth from Surface. Ft.	Ins.	Remarks.
1	Marl, with gullets	140	2	Water-feeders reduced from

[redacted]

The making of the crib-beds, laying the cribs and putting on the tubbing and wedging of the same were rapidly done, the dryness of the pit ond other conditions being very favourable for this work (Table IV.)

On approaching the drift from the Theresa shaft, bore-holes were put down to prove that it was properly frozen before holing into it. The top portion of the drift was found to be solid ice. The drift (Fig. 39), filled with sand frozen hard, was eventually timbered off.

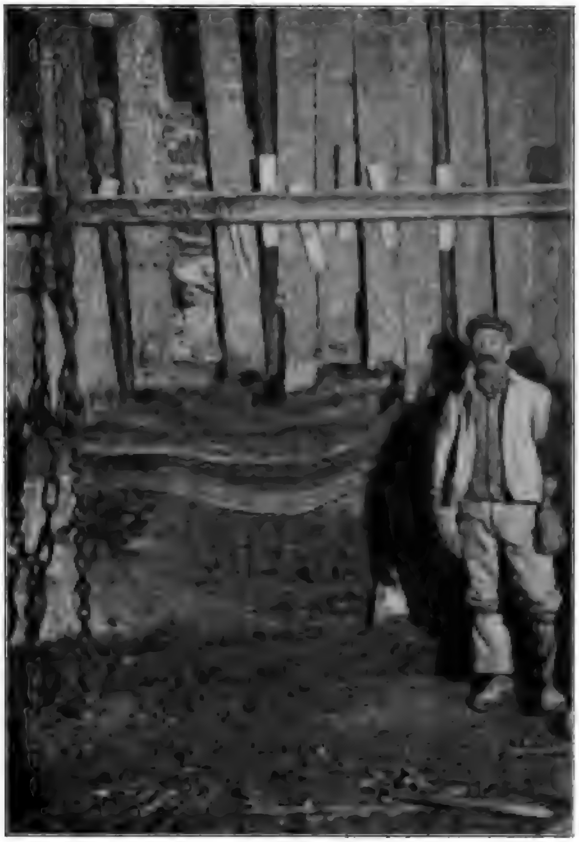

Fig. 39.—Drift between the Castlereagh and Theresa Shafts, as found in the Castlereagh Shaft.

When working at the level of the drift, the opportunity was taken to cut out the rock and to expose No. 16 freezing-tube, part of which was eventually cut out at that point (Fig. 38). A new hole was bored from the surface, through the top freezing-tubes and through the ice-wall, into the Coal-measures, and small freezing-tubes were inserted in it.

When the last length of tubbing had been inserted, and wedged in the Magnesian Limestone at a depth of 356 feet 11¾ inches before entering the sand, bore-holes were put down

with rock-drills, through special stuffing-boxes (Fig. 26, Plate XXXII.), to avoid an inrush of water, to prove whether the sand was frozen. Five bore-holes were attempted: Nos. 1 and 5 holes were lost through the rods freezing in the holes; No. 2 hole was bored 51 feet 2 inches; No. 3 hole, 18 feet 6 inches; and No. 4 hole, 25 feet. The strata passed through in No. 2 hole comprized limestone, 8½ feet; fish-bed and shale, 3½ feet; and into frozen sand, 39 feet.

On July 22nd, 1905, the sand was struck at a depth of 371 feet, and found to be frozen hard. So great was the intensity of the freezing, that the sand resembled hard grey freestone, although pieces readily crumbled away when held for a short while in the hand. On being exposed to the atmosphere the sand soon became soft and fell to pieces. In the shaft-bottom, the frozen sand was so hard that blasting had to be continued throughout the deposit. The upper portion of the frozen sand was tested, and found to contain 12 per cent. of water. Some of the ground passed through towards the bottom contained a very much larger percentage of water, and girdles of ice intermingled with the sand exposed in the sinking, proved the previous presence of free water. The temperature of the frozen sand in the bottom of the pit was $-14°$ Cent. (6·8° Fahr.).

The Yellow Sand was found of two colours: blue-grey sand, 75 feet thick; and brown-grey sand, 17 feet 4 inches thick.

At the bottom of the sand, lying unconformably on the Coal-measures, there was a hard irregular mass, about 1 foot

[redacted]

in the frozen sand; and a metal crib and foundation-course, 18 inches wide, was laid, and a lift of tubbing, backed with concrete was inserted.

On August 2nd, 1905, the Yellow Sand was passed through, and the sinking entered the dark-grey shale of the Coal-measures. The sinking was continued 7 feet into the Coal-measures; and a crib-bed was formed in the frozen ground at a depth of 468 feet 4 inches. A metal crib and foundation-course, 15 inches wide, was laid, a length of tubbing, backed with concrete, was put in, and the sand was closed off. On shearing back, to make the last named crib-bed, Nos. 6 and 7 freezing-pipes were exposed: No. 6 pipe, *c*, just cleared the metal crib, but No. 7 pipe, ***d***, had to be cut out to allow the metal crib to be laid (Fig. 6, Plate XXVIII.).

Sinking was resumed to a further depth of 49 feet, and the bottom of the ice-wall or frozen ground passed through (Fig. 30, Plate XXXIII.).

On August 18th, 1905, a crib-bed was laid at a depth of 510 feet 6 inches, and a lift of tubbing was built from it.

The bottom foundation crib-beds were made at a depth of 535 feet 1 inch. Two metal foundation-cribs, the bottom one 18 inches wide and the top one 22 inches wide, were laid, and the tubbing was completed (Fig. 31, Plate XXXIV.).

The section of the metal tubbing put into the shafts was $\frac{7}{8}$ inch thick at the water level, increasing $\frac{1}{8}$ inch for each 60 feet in depth, the bottom length being $1\frac{1}{2}$ inches thick.

On September 25th, 1905, when sinking through the Coal-measures in the frozen ground, at a depth of about 486 feet while drilling sump-holes, one of the holes struck a feeder of water under sufficient pressure to force a jet of water 20 feet up the shaft and of very low temperature. The hole was plugged, but when the pressure was allowed to run off, the quantity of water was found to be very small. It was thought that the water had come from a "pocket," which had not been frozen, and that it had been subjected to great pressure owing to the expansion of the frozen ground.

Theresa Pit.—Sinking in the frozen ground was effected in the Theresa shaft on somewhat the same lines as at the Castlereagh shaft.

The sinkers were sent into this shaft on August 14th, 1905,

to take out the ice on the sides of the tubbing and in the bottom of the shaft (Fig. 40). When all the ice had been removed, three holes were bored through the concrete to ascertain whether the underlying ground was thoroughly frozen. Leading bore-holes were kept in advance, until the drift to the Castlereagh shaft was passed and the Magnesian Limestone struck at a depth of 354 feet. Three holes were bored in the bottom of the pit to prove the thickness of the Magnesian Limestone, and they were stopped at a depth of 15 feet (Table V.).

On sinking 11 feet into the limestone, a crib-bed was made at a depth of 354 feet $11\frac{1}{2}$ inches, and a lift of tubbing in-

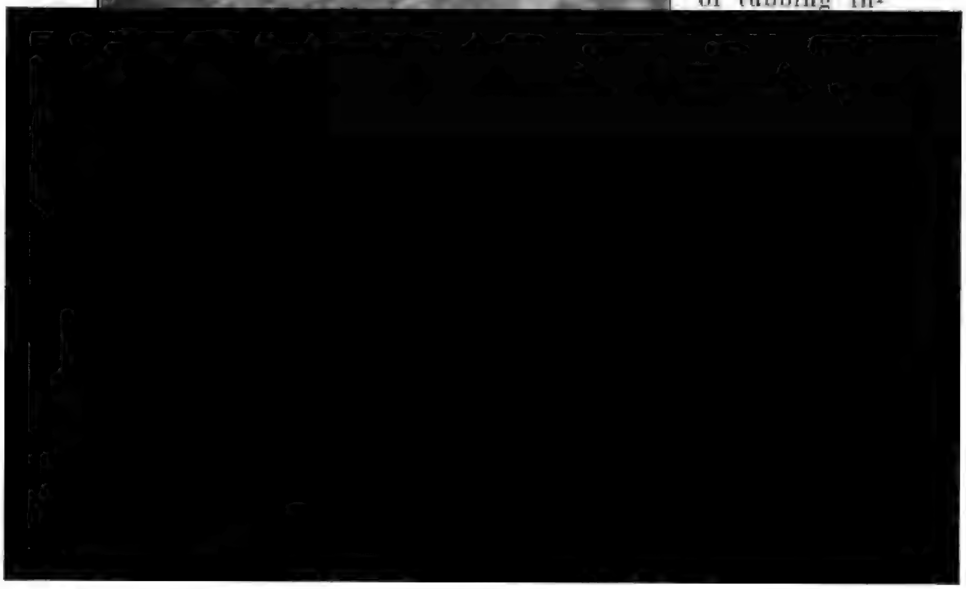

TABLE V.—SECTION OF STRATA SUNK THROUGH IN THE THERESA SHAFT, DAWDON COLLIERY.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
	Alluvium—				
1	Soil	1	0	1	0
2	Clay	5	0	6	0
3	Gravel	3	0	9	0
	Magnesian Limestone—				
4	Marl, with hard limestone panels	6	1	15	1
5	Marl	22	6	37	7
6	Limestone	6	0	43	7
7	Strong bedded marl	66	0	109	7
8	Strong marl, in blocks	64	8	174	3
9	Hard limestone, honeycombed ...	60	6	234	9
10	Grey marl	4	7	239	4
11	Grey limestone	73	4	312	8
12	Grey limestone, with large gullets, filled with yellow limestone	23	4	336	0
13	Hard grey limestone	31	0	367	0
	Marl Slate— Ft. Ins.				
14	Soft shale ... 0 1				
15	Hard shale ... 1 3				
		1	4	368	4
16	Fish-bed	0	10½	369	2½
	Yellow Sand —				
17	Blue-grey sand ...	78	5	447	7½
18	Brown-grey sand ...	14	7½	462	3
	Coal-measures—				
19	Very hard post-girdle	1	1	463	4
20	Dark-grey shale, with red shale-bands	18	7	481	11
21	COAL	0	3	482	2
22	Grey shale	2	10	485	0
23	COAL	4	8	489	8
24	Grey post	1	9½	491	5½
25	Seggar-clay ...	10	7	502	0½
26	COAL	0	11½	503	0
27	Grey shale	6	0½	509	0½
28	Dark-grey shale ..	2	1	511	1½
29	COAL	0	3¼	511	4¾
30	Dark-grey shale ...	0	9¼	512	2
31	Grey post, with shale-partings ...	1	11	514	1
32	Very hard grey post	1	10	515	11
33	Grey post, with shale-partings ...	4	11	520	10
34	Dark-grey shale ...	1	2	522	0
35	Post-girdle ...	0	2	522	2
36	Dark-grey shale . .	0	10	523	0
37	Grey post	2	6	525	6
38	Grey shale	13	0	538	6
39	COAL	3	4	541	10
40	Seggar-clay ...	4	11	546	9
41	Grey shale	2	11	549	8
42	COAL	0	7	550	3
43	Seggar-clay ...	4	9	555	0

TABLE VI.—ACCOUNT OF THE CAST-IRON WEDGING-CRIBS IN THE THERESA SHAFT, DAWDON COLLIERY.

No. of Crib.	Description of Strata forming the Bed of the Crib.	Depth from Surface. Ft.	Ins.	Remarks.
1	Hard limestone, honeycombed ...	196	2	Water-feeders reduced from 6,075 to 1,100 gallons per minute.
2	Hard limestone, honeycombed ...	226	9	Water-feeders reduced from 2,850 to 1,470 gallons per minute.
3	Grey marl	236	5	Water-feeders reduced from 1,560 to 400 gallons per minute.
4	Grey limestone, with large gullets, filled with yellow limestone	327	11	Water-feeders reduced from 1,720 to 380 gallons per minute.
5	Hard grey limestone, frozen ...	354	11½	Frozen ground.
6	Blue-grey sand, frozen	390	5½	Do.
7	Blue-grey sand, frozen	431	5½	Do.
8	Dark-grey shale, with red shale-bands, frozen	468	7	Do.
9	Grey shale	508	4	—
10 and 11	Grey shale	530	9	Double wedging-crib.

sinking through the sand. After 34 feet had been sunk in the sand, a crib-bed was made at a depth of 390 feet $5\frac{1}{2}$ inches in the frozen ground and a metal crib with a foundation-course, 15 inches wide, and tubbing, backed with concrete, to secure the top portion of the sand and fish-bed, was inserted. Sinking was again continued for 45 feet 3 inches in the frozen sand; a second crib-bed was laid at a depth of 431 feet $5\frac{1}{2}$ inches and a metal-crib with a foundation-course, 15 inches wide, and tubbing, backed with concrete, was inserted.

[redacted]

(*f*).—*The Thawing of the Frozen Ground.*

One of the refrigerator-tanks was disconnected from the ammonia-circuit, in order that it might be used to thaw the frozen ground, to allow of the withdrawal of the tubes, and to allow of the pressure of water coming gradually upon the tubbing. A steam-pipe was connected to the spiral tube, and a circulating pump was coupled to the tank and to the collectors of the freezing-tubes at the shaft. The tank was then filled with brine, and steam was passed through the spiral tubes, warming the brine which was circulated by the pump through the tubes in the shaft.

Castlereagh Shaft.—The temperature of the brine, −18° Cent. (−0·4° Fahr.), left in the freezing-tubes at the end of the freezing of this shaft on October 19th, 1905, was found, on November 6th, 1905, to have risen to 0° Cent. (32° Fahr.).

The circulation of warm brine was commenced on November 7th, 1905. The temperature of the brine going to and returning from the shafts is recorded in Table VII.

TABLE VII.—TEMPERATURES OF THE BRINE EMPLOYED IN THAWING THE ICE-WALL AT THE CASTLEREAGH SHAFT.

	Temperatures of Brine: Going to Shaft. Degrees Cent.	Going to Shaft. Degrees Fahr.	Returning from Shaft. Degrees Cent.	Returning from Shaft. Degrees Fahr.
1905.				
Nov. 9	5	41·0	0	32·0
,, 20	28	82·4	20	68·0
,, 23	31	87·8	22	71·6
,, 29	17	62·6	13	55·4
Dec. 4	20	68·0	17	62·6
,, 8	21	69·8	18	64·4

On November 26th, 1905, 19 days after beginning to thaw the ice-wall, a pressure of water was found to exist behind the tubbing, and a plug was blown out of one of the segments, 255 feet below the surface.

A large coke-fire lamp or brazier was suspended by chains to the sinking rope, on December 1st, 1905, and run slowly up and down the shaft to heat the air and melt the ice on the top lengths of tubbing and on the brickwork near the surface.

Two pressure-gauges were fitted to the tubbing to record the pressure of water behind it: one, placed at a depth of 306

feet below the top of the tubbing, recorded a pressure of 130 pounds per square inch; and the other, at a depth of 360 feet, recorded a pressure of 160 pounds per square inch.

The circulation of warm brine was maintained until January 2nd, 1906.

Theresa Shaft.—The same system of thawing was used in the Theresa Shaft as that used at the Castlereagh shaft. Warm brine was circulated from February 28th to May 4th, 1906.

Three holes were drilled, with an auger, $\frac{3}{8}$ inch in diameter, through the sheeting below each of the cribs of the tubbing, in both shafts, to be used for ascertaining what was taking place behind the tubbing during the thawing of the ice-wall. These holes acted as vent-holes both for air and water as the ice-wall thawed and prevented any "air-lock" from taking place. Water was allowed to run from them until the ice-wall was thoroughly thawed, and they were then wedged tight.

(*g*).—*Removal of the Freezing-tubes.*

Castlereagh Shaft.—The drawing of the tubes from the Castlereagh shaft was commenced on February 21st, 1906. The central tube was taken out of each hole. The freezing-tubes were removed by means of a drawing tool, which was lowered into the tube, at the end of solid-steel rods, a pair of clamps was bolted round the rods, and an upward pressure was brought [redacted]

Table VIII. records the lengths of freezing-tubes that were lost in the respective holes.

The withdrawal of the freezing-tubes at the Castlereagh shaft was finished on April 17th, 1906, 8 weeks from the commencement.

Theresa Shaft.—On May 2nd, 1906, the withdrawal of the central and freezing-tubes was commenced, and the whole of the tubes were withdrawn, none being lost, on May 25th, 1906, 3 weeks and 2 days from starting.

The bore-holes at each shaft were filled with gravel and sand, after the tubes were extracted, the upper portion of the holes near the surface, in some cases, being filled with cement-concrete.

The writer is greatly indebted to Mr. V. W. Corbett, mining agent and director of the Londonderry Collieries, Limited, under whose management the works in connection with the Dawdon winning have been successfully carried out, for permission to publish the facts and information detailed in this paper.

Mr. T. E. Forster said that one point was very clearly brought out in Mr. Wood's paper, and it would probably explain what had happened in other sinkings, namely, the necessity of preventing any circulation of the water. The diagrams showing that, until a sufficient quantity of concrete was thrown into the pit, the circulation of the water could not be stopped, were very interesting. Probably, when sinkings had to be made by this process, it would be better that the freezing should be commenced from the top. He would like to ask whether there was any difficulty with the tubbing when the ground was thawed. He was under the impression that the tubbing used at Dawdon was that ordinarily used in the district, and was not fitted with flanges inside the pit and bolted together. He would like to know what thickness of concrete-backing had been used.

Mr. E. Seymour Wood said that no difficulty had been experienced with the tubbing, when the ice-wall was being thawed; the only thing that happened to it was the blowing out of one of

the plug-holes. The entire tubbing was backed with concrete, 4½ inches thick, through the whole depth of the Yellow Sand, up to the Magnesian Limestone.

Mr. BENNETT H. BROUGH (London) noted with interest that the results of the author's experience proved that the plumbing of bore-holes was an absolutely untrustworthy method of determining the deviation from the vertical. Various ingenious devices had been described* for determining the deviation, by means of a magnetic needle enclosed in a glass-phial filled with a hot solution of gelatine, by etching glass with hydrofluoric acid, and by an electric recording apparatus. With an instrument of the last-named type, Mr. H. F. Marriott† had detected enormous bore-hole deviations at the Turf mines, Johannesburg. For surveys of bore-holes in connection with the freezing process of shaft-sinking, excellent results had been obtained with instruments of the stratameter class, in which a compass-needle and a plumb-bob were regulated by clockwork. The various instruments of that class were described in detail in a recently published work by Mr. F. Freise.‡

The PRESIDENT (Mr. J. H. Merivale), in proposing a vote of thanks to Mr. Wood for his paper, said that that gentleman and the owners of the colliery were to be congratulated on having completed their difficult, expensive and arduous sinking by the freezing system.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

CUTANEOUS INFECTIVITY OF ANKYLOSTOMIASIS.

L'Infezione da Anchilostoma per la Via cutanea. By GINO PIERI. *Atti della Reale Accademia dei Lincei*, 1905, *series* 5, *Rendiconti, vol. xiv., pages* 547-554.

Premising that he has been at work on this important subject since 1901, the author gives an account of the experiments which he has carried out in the Laboratory of Comparative Anatomy directed by Prof. B. Grassi.

On December 4th, 1901, he placed on his own skin, and on that of Drs. B. Grassi and Noé, several thousands of larvæ of *Ankylostoma*, but the results are described as inconclusive. Further experiments, in the course of 1903, were purely negative in regard to the transmission of the infection through the skin. But, as a result of the experiments made on dogs by the author in the course of 1905, and of the evidence accumulated by other experimenters, he admits unreservedly that ankylostomiasis can be transmitted through the skin by mature larvæ. Nevertheless, he regards ingestion through the mouth as the principal mode of infection, and adduces the evidence in favour of this contention, as against the contrary opinion upheld by Drs. Calmette, Breton and Liebmann (that infection through the skin is the chief cause of the trouble).

He also lays stress on the following points: (1) Not all the larvæ that come into contact with the skin pierce through it; (2) not all the larvæ that do pierce through the skin actually reach the intestine; and (3) the experiments on animals show that the older the subject of the experiment is, the less easily, rapidly, and abundantly, does infection through the skin take place.

L. L. B.

MINING LEGISLATION IN HOLLAND.

Note sur la Législation Minérale des Pays-Bas. By J. G. BOUSQUET. *Annales des Mines*, 1905, *series* 10, *Mémoires, vol. vii., pages* 123-140.

Until recently the mining code of the Netherlands consisted purely and simply of the French law of April 21st, 1810, subsequently modified in some respects as to its form. It is true that the law was interpreted by the Dutch Government in a fashion that did not accord with French or Belgian notions of jurisprudence, those who applied for mining concessions being compelled to agree to certain additional clauses (in the matters of expiry of lease, preliminary security, etc.) which would be regarded as illegal in France or Belgium.

Consequent on the discovery in Dutch Limburg of that coal-basin, which has since been found to extend westward into Belgian Limburg, the Campine, and the province of Antwerp, the Dutch Government felt impelled to supplement and modify previous legislation by the enactment of the laws of June

21st, 1901, July 24th, 1903, and April 27th, 1904. A French translation of the full text of these laws is given by the author in an appendix.

There appeared to be little doubt that the discovery of the new coal-basin was destined to bring about great changes in the industrial position of the Netherlands, but the key-note of the situation was the fixed determination of the Government to reserve for the State at least a certain portion of the coal-field. As the result of the bore-holes, there was in 1898 a race for mining concessions on the part of sundry capitalists. Finding that the task of allotting these equitably would probably prove all but impossible, the Dutch Government instituted in 1899 a special Commission to investigate the whole question. The results of the enquiry may be summed up as follows:—The area over which workable coal-seams extend in Dutch Limburg amounts to 35,830 acres, of which part should be reserved for working by the State. This reserved portion would cover about 11,120 acres, and probably contains about 820 million tons of coal. The remainder should be allotted in concessions of not less than 1,235 and not more than 2,471 acres, in order to encourage legitimate competition. It was noted, by the way, that most of the existing concessions were in the hands of foreign capitalists or foreign syndicates, and that the demands for fresh concessions totalled up to an area which was more than three times that of the proved coal-field. Weighty reasons were assigned for the State-working of a portion of the coal-field, one being that the State-mines would serve as a model or a standard for the private collieries to work up to; also, that consumers would thereby be protected from the abuses that arise from the formation of rings or trusts. As a people, the Dutch have no great bent towards mining enterprise nor much experience in it; and, if the State did not intervene, the Commission foresaw that all the new mines would fall into the hands of foreigners. The Government, in 1901, presented a bill based on these conclusions to Parliament, but the drastic resolution was passed to reserve the entire area of 35,830 acres for working by the State; then by the law of 1903, the Government reserved to itself the right of searching for coal north and east of the known coal-field for six years thereafter, leaving very little ground open to the enterprise of private prospectors. By the law of 1904, the abrogation of concessions, when granted, is declared, if mining operations have not been [redacted]

extremely hard, light, and short, suspended by very elastic brass wires within a long steel shell which was screwed to the lower extremity of the boring-rods. The results proved that the average value of the geothermic degree in the Silurian and Devonian strata, consisting of a succession of clay-slates and quartzitic grits many times repeated, is expressed in terms of depth by 185½ feet; this implies that the conductivity of these rocks is very great indeed. The results obtained by the author in the Cretaceous rocks and in the Coal-measures are too divergent to permit of an average being struck; but, at Drocourt, near Fresnoy, the geothermic degree of the Coal-measures is expressed in terms of vertical depth by 132½ feet. Calling the geothermic degree n, the conductivity of a given rock k, and the vertical flow of heat per unity of surface q, the author shows that $n = q/k$. The practical result of the measurements recorded by him is, that at a depth of about 4,000 feet, the new pits to be sunk in the south of the Pas-de-Calais will have to deal with temperatures varying between 95° and 105° Fahr. At the same depth in Lorraine, the temperatures already met with in the new bore-holes for coal range from 120° to 130° Fahr.

L. L. B.

SEASONAL DISTRIBUTION OF EARTH-TREMORS.

(1) *Sur les Lois de Répartition mensuelle des Tremblements de Terre.* *By* F. DE MONTESSUS DE BALLORE. *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie*, 1906, *vol. xx.*, *Procès-verbaux*, *pages* 183-191.

The author points out that it is a merely fortuitous coincidence that, in temperate regions, seismic phenomena appear all the year round to follow the variations of the barometer. Barometric pressure can hardly be invoked as a factor, with any sense of proportion, in the case of those earthquakes which are of deep-seated origin. These macroseismic phenomena must be regarded as entirely distinct from microseismic movements, which are mere minor vibrations of the most superficial portion of the earth's crust, due to an infinite variety of causes—some of these causes being hardly determined or understood as yet.

(2) *Sur les prétendues Lois de Répartition mensuelle des Tremblements de Terre.* *By* F. DE MONTESSUS DE BALLORE. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxliii.*, *pages* 146-147.

Collating the records of about 60,000 earthquakes from 81 different catalogues, which the author has recently examined, he arrives at the result that the maximum of apparent seismic frequency occurring in October to March in latitudes higher than 45 degrees is 90 per cent., and from April to September 10 per cent.; and from October to March in latitudes lower than 45 degrees, 47 per cent., and from April to September, 49 per cent. (4 per cent. being neither maximum nor minimum). Therefore, northern regions (lying in latitudes higher than 45 degrees) show an enormous predominance of the maximum apparent seismic frequency during the cold season, while the southern regions (lying in latitudes lower than 45 degrees) are comparatively neutral in this regard.

Remembering that the number of slight earth-tremors is incomparably greater than that of strong or violent shocks, and that the average man if within doors and resting perceives the slighter tremors far more easily than when he is out of doors and engaged in active work, these results are immediately explicable. In the northern regions, it is in the cold season, from October to March, that people spend most of their time indoors, and that there is least outdoor work done; whereas in the southern regions the conditions of life are

much the same all the year round. The personal factor furnishes thus a key to this supposed seismic maximum in winter; and the conclusion remains that earthquakes are equally likely to occur at any season of the year.

L. L. B.

EARTH-TREMORS IN GREECE DURING THE YEARS 1900 TO 1903.

Étude des Séismes survenus en Grèce pendant les Années 1900-1903. *By* D. EGINITIS. *Annales de l'Observatoire National d'Athènes*, 1906, *vol. iv., pages* 135-145.

Some account is given of the progress recently made in the organization of the Hellenic geodynamic department, started by the author at the Athens Observatory in 1892. Several hundred workers, stationed in various localities all over the kingdom, are entrusted with the systematic observation of earth-tremors; and at five localities (Athens, Calamate, Chalcis, Zante and Egion) the observing-stations are now equipped with Agamennone seismographs.

From January, 1900, to December, 1903, inclusive, no less than 1,284 seismic shocks were recorded in Greece, the greatest number in any one year (414) being observed in 1902. The annual average for the quadrennium (321), is very much less than the annual average (531) observed in the years 1893 to 1898; while in the year 1899 no less than 567 seismic shocks were recorded. The only shock that had destructive effects during the period under review, was the sufficiently violent earthquake which centred in the island of Cythere. All the other shocks were comparatively feeble, especially in relation to their frequency. The general monthly average was 27, as compared with a monthly average of 44 shocks in the years 1893 to 1898; in both periods, however, it is noteworthy that shocks were more frequent in the cold than in the hot season. Seismicity appears to increase from November to February, and thenceforward diminishes almost continuously until October, the months of greatest earthquake frequency being January, February, March and April. With regard to diurnal frequency, shocks appear to be more numerous by night than by day, the maximum occurring between 10 p.m. and 4 a.m., and more especially between 2 a.m. and 4 a.m. And this contrast cannot be put down to the fact that, in the quiet of the nocturnal hours, shocks are more easily [redacted]

EARTHQUAKE OF 1905 IN CALABRIA, ITALY.

(1) *Il grande Terremoto calabro dell' 8 Settembre 1905. By* MARIO BARATTA. *Atti della Società toscana di Scienze naturali,* 1906, *Memorie, vol. xxii., pages* 57-80, *with* 2 *figures in the text.*

A slight fore-shock was felt by some persons at about 11 p.m. on September 7th; but the principal shock started about 2·45 a.m. on the 8th, with a thrice-repeated violent saltatory motion, succeeded after an interval of a couple of seconds by undulatory movements of variable direction, giving the impression of torsional motion, and lasting for at least 35 seconds. A loud rumbling noise, comparable to the thunderous roar of a heavy railway-train entering a tunnel, began a little before the shock, and lasted throughout it with increasing intensity. The town of Monteleone suffered serious damage, a great number of buildings being wholly or in part reduced to ruins, or at least rendered uninhabitable. A very few houses escaped, owing to their exceptionally solid construction and to the direction in which they were oriented. This town furnishes another example of the fact that buildings founded on solid rock are, by comparison with those the foundations of which rest upon a rubbly or loose subsoil, comparatively immune to seismic phenomena.

A description is given of the destructive effects of the earthquake in the outlying villages, and the author observes that, poor as the general type of building is in Monteleone itself, the methods and materials in use in these villages are still more open to criticism. At Stefanaconi, 65 persons were killed on the spot, and 30 were seriously injured; Piscopio, a village numbering 1,162 inhabitants, was utterly destroyed, 59 persons being killed and 250 injured; 84 were killed in the parish of San Gregorio d'Ippona, where the bell-tower of the church crashed to the ground. At Cessaneti, the same phases of saltatory and undulatory motion were observed as at Monteleone; 7 persons were killed, and half a score injured. The havoc wrought was much greater in all those cases where buildings were founded on loose or rubbly subsoil. This factor is of equal importance, in appraising the result of earthquakes, with the architectural factor (mode of building and materials used).

The earthquake of September 8th is termed by the author "polycentric," because within the area of greatest intensity there was a principal epicentrum in the Monteleone district; another one in the neighbourhood of Ajello-Martirano; and, in all probability, a third in the belt defined by Montalto-Uffugo-Rende.

(2) *Sur le Tremblement de Terre calabrais du 8 Septembre 1905. By* G. MERCALLI. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences,* 1907, *vol. cxliv., pages* 110-112.

This author points out that the following phenomena were monitory forerunners of the great earthquake: (1) two minor shocks which took place between September 3rd and 8th, in the Basilicata region; (2) a preliminary recrudescence of activity in the Stromboli volcano, and a very apparent earth-tremor throughout Western Calabria on the morning of August 29th; (3) a great increase of hydrogen sulphide in the thermal waters of Sambiase (Nicastro); and (4) a slight earth-tremor, which was felt about 1 hour before the principal shock, throughout the area subsequently devastated by that shock. The great Calabrian earthquake was unaccompanied by any permanent dislocation of the subsoil, and so the author classifies it among the seisms which are usually termed "perimetric," but to which he assigns the appellation "intervolcanic." The devastated area included no less than 44 villages or hamlets; it measured 62 miles in length from Bisignano to Mileto, and 25 miles in its

greatest breadth between Olivadi and Briatico. That the epicentrum was deepseated is shown by the fact that the earthquake was recorded by the instruments in all the seismological observatories of Europe, and as far afield as Japan and the Philippines, Toronto and Cape Town. The complication and the variability in direction of the movements—saltatory, undulatory and giratory, already mentioned in Dr. Baratta's memoir—are attributed by Dr. Mercalli to the resurge of the seismic waves from against the mass of crystalline rocks which ranges throughout the devastated area, and also to displacement of the epicentrum in the course of the earthquake. The very irregular distribution of the damage to buildings, etc., was due to a variety of causes. Given equal intensity, the seismic movements wrought greatest havoc in villages built on slopes or on isolated, not very extensive, eminences; also in those built on the Pliocene yellow sands, on the loose Miocene molasse, on patches of Quaternary alluvium and on talus-slopes, or on the rubble formed by the subsoil decomposition of the crystalline rocks. Moreover, the effect of the shock was most disastrous at the contact of these rocks and the overlying Tertiary or Quaternary deposits, on account of the sudden stratigraphical unconformity coinciding with a great difference of elasticity in the mass through which the earthquake was travelling. The great loss of life is largely attributable to the wretched structural conditions of the habitations, which were mostly old and but scantily repaired after having been damaged in previous earthquakes. Dr. Mercalli, after very careful investigation, arrived at the conclusion that there were really two epicentra: one in the Monteleone district, and the other in the south-western portion of the upper valley of the Crati. Numerous after-shocks, no less than 100 in the first three months, followed hard upon the principal earthquake. He assigns reasons for rejecting any causal connexion between the coincident renewed volcanic activity of Stromboli and of Vesuvius and that earthquake; probably both the volcanic and the seismic manifestations were due to certain endogenic influences, to which all the geodynamic phenomena of the region may be ultimately traced.

Although the sea was calm, and there was no wind after the principal shock, the waters rose and fell, with a periodicity of 7½ minutes, along the entire Tyrrhenian coast of Central Calabria, the difference from the normal level attaining at some points a maximum of 4½ feet. L. L. B.

[redacted]

"tremor-apophyses" can be traced stretching into Southern Finland and Russian Karelia. It is noteworthy that all the records come from localities situated on a comparatively loose soil (that is, where the immediate substratum is not solid rock).

In the epicentral area and its immediate neighbourhood, the phenomenon is described as resembling the roar of an oncoming wind, followed by a very perceptible undulation of the ground, or in places one or two saltatory motions, and then a general vibration of the soil. Without the immediate neighbourhood of the epicentral area, the separate motions were merged into one. The direction of propagation is a matter on which extremely various reports have been obtained: on the whole, it is described either as being from north-west to south-east, or as precisely the reverse. During the earthquake a sound was heard comparable to the clattering of rapidly driven carts, and an ominous cracking in the roofs. Windows rattled, suspended objects swung to and fro, small fissures appeared in the walls of buildings, and many persons were aroused from sleep. Church-towers were especially shaken, and in some localities a screw-like twisting motion was observed. The weather was calm and very cold, and the barometer much above the normal height. No magnetic disturbances were recorded.

There appears to be little doubt that this is a case of an earthquake originated by faults. The main tectonic lines of the region have the same strike as the principal axis of the epicentral area. Possibly the enormous transport of sediment (? removed by erosion) still taking place from this district is contributing to changes in crust-pressure. Moreover, so far as can be ascertained, secular elevation of the land is more marked to the south-west of the epicentral area than within it. L. L. B.

CHILIAN EARTHQUAKE OF AUGUST, 1906.

Einige Ergebnisse der Untersuchungen über das mittelchilenische Erdbeben vom 16. August 1906. By HANS STEFFEN. *Petermanns Mitteilungen*, **1907**, *vol. liii., pages* 132-138 *and a map.*

In the macroseismic area embraced by the so-called Valparaiso earthquake of August 16th, 1906, covering practically a fifth of the South American continent, only one reliable seismographic record is forthcoming—that, namely, furnished by the Milne horizontal pendulum at Pilar, in the Argentine province of Córdoba. In the region west of the Cordilleras where the most violent shocks occurred, some, what may almost be termed fortuitous, records were obtained from a few primitive instruments set up by amateurs; these yielded detailed results only in regard to the direction and intensity of the shock. The author has, however, been able, by various methods, to bring together sufficient material for forming a considered opinion as to the general character of the phenomena.

The shocks perceptible to the ordinary human senses were observed over the greater part of the South American continent south of latitude 18 degrees south, from Tacna at the northern extremity of this triangular area to the island of Chiloé at the southern extremity. On the east, the line of the Rio Paraná-Rio de la Plata may be regarded as defining the boundary of the macroseismic belt, although on the north-east that boundary is uncertain. On the west, the Juan-Fernandez archipelago, lying over 400 miles distant from the coast at Valparaiso, is the probable boundary. However that may be, the north-to-south extension of the earthquake (1,740 miles) had only been exceeded in the Chile-Peru coastal belt on one previous occasion—the disastrous shock of May 9th, 1877; while no sufficiently reliable data of the east-

to-west extension of former earthquakes are available for comparison in that direction.

The first perceptible shock on August 16th, 1906, took place about 7·56 p.m., and in the central portion of the macroseismic area it lasted as long as 4 or 5 minutes, being succeeded after an interval of comparative tranquillity by a more violent shock of barely one minute's duration. The relatively quiet interval at Santiago cannot have lasted less than 4 minutes. At Pilar, 435 miles away on the other side of the Andes, the seismographic record chronicles a fore-shock of 9·7 minutes' duration, followed by a principal shock of 12 minutes' duration, then by a succession of alternately feebler and more violent shocks lasting for about an hour, after which the gradual decrease of the vibrations was perceptible for a further 77 minutes, the total duration of the phenomena being thus somewhat over 2¼ hours. In the remoter portions of the macroseismic area the differentiation of the two phases was not perceptible, the phenomena being described as a remarkably long succession of undulatory vibrations of uniform intensity. From 30 degrees to near 38 degrees south latitude, and from the base of the great Cordilleras to the Pacific sea-board, very marked vertical movements (in the form of fairly-violent saltatory vibrations) were undoubtedly observed. It would almost seem as if the entire macroseismic area above defined had been suddenly imbued with a tendency to centrifugal motion.

The horizontal vibrations appear to have been propagated in all directions, no single direction being really predominant, and in the epicentral area there seems to have been actually torsional movement,

With regard to the intensity of the earthquake, the Commission of Enquiry appointed by the Chilian Government preferred to make use of the Mercalli scale (despite its acknowledged defects) instead of the Rossi-Forel scale. The map constructed on that basis shows that the pleistoseismic area (seventh to tenth in the scale) embraces the central portion of Chile, between 31½ degrees and 38 degrees south latitude, from the western base of the Cordilleras to the shores of the Pacific, the isoseismals defining a series of elongated semi-ellipses. The major axes of these, for at all events a distance of 310 miles, coincide approximately with the coast-line; but at the northern extremity they trend more inland, their general strike being north 18 degrees east. The concentricity

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The circumstance that, shortly before the commencement of the earthquake, heavy showers of rain were experienced over the whole of Central Chile, appears to have ominously intensified the seismic phenomena in many localities. Thus the little town of Limache was razed to the ground, and out of its 3,500 inhabitants no less than 116 perished on the spot; the surface-soil there, a loose sand some 4 feet thick, overlies an impermeable clay (over 2½ feet thick), and so is water-logged after heavy rains. So, too, in the sand-dune region, which occupies a great extent of the Chilian coast, the effects of the earthquake were conspicuously manifest—thus San Antonio, a settlement north of the mouth of the Rio Maipu, was buried by the shifting and collapse of a dune.

The intensity of the earthquake seems to have diminished far more rapidly northward than southward, in the coastal region at all events. On the whole, however, the isoseismals coincide more or less closely with the tectonic lines defined by the Pacific sea-board, the Central Chilian longitudinal plain, and the Cordilleras of the Andes. In the southern latitudes, as far as the entrance of Aranco Bay (37 degrees south latitude), no exceptional motion of the sea was observed in association with the earthquake-phenomena; but at Coronel, on the northern shore of that bay, there was a tremendous swell, although the ocean remained unrippled by the slightest breath of wind. At Penco, which had on previous occasions suffered from these so-called tidal waves, the threefold and fourfold repetition of such waves accompanying the earthquake here described sent the panic-stricken inhabitants on the trot for the neighbouring hills. Other seaside localities report similarly alarming waves; but, singularly enough, still farther north, along the coasts of the provinces of Colchagua, Santiago, Valparaiso and Aconcagua, which suffered most severely from the earthquake, there was nothing abnormal in the behaviour of the Pacific. The source of the tectonic disturbance which gave rise to the earthquake must not be sought in the depths of that ocean.

There is not sufficient evidence at hand to determine whether the tidal wave observed on the shores of the Hawaii islands was in reality associated with the Chilian earthquake; but, on the whole, the balance of the recorded facts tells against such an hypothesis.

Perhaps one of the most interesting features of the earthquake of August 16th, 1906, is the slight elevation of the coast-line in certain districts with the exception of those lying north of 31½ degrees south latitude and south of 35 degrees south latitude. This elevation coincides, where it is most marked, with the areas of highest seismic intensity, and appears to have attained its maximum (which never exceeded 2·65 feet) in the north. In the Valparaiso area, after-shocks were still being felt almost daily in March, 1907, that is, seven months subsequently to the principal shock. L. L. B.

EARTHQUAKES OF 1906 AT MASAYA, NICARAGUA.

Erdbebenserie von Masaya (Nicaragua), 1. bis 5. Januar 1906. *By* KARL SAPPER. *Centralblatt für Mineralogie, Geologie und Paläontologie*, 1906, *pages* 257-259, *with a map in the text.*

At 10·30 p.m. on December 31st, 1905, a premonitory fore-shock was felt, followed at about 5·30 a.m. on New Year's day by a shock sufficiently violent to cause general excitement in the district. Meanwhile rumblings were heard at every few minutes' interval, supposedly from the volcano of Santiago, 10 miles or so to the west of the town of Masaya. Light earth-tremors accompanied the rumbling. About 5 p.m., the inhabitants were alarmed by a still

more violent shock, and at 6 a.m. on January 2nd, another earthquake took place, causing damage to several buildings, many persons being injured by falling masonry. A series of fifteen lighter shocks followed in the course of the morning, and four more violent shocks took place between noon and 7·30 p.m. The night was in comparison tranquil, but light tremors occurred with almost mathematical precision every 2 minutes. Three violent shocks took place on the morning of January 3rd, while the subterranean rumblings and slight tremors were practically continuous. The seismic phenomena recurred in a violent form on January 5th (the shocks on January 4th being comparatively unimportant), and in the latter half of the day altogether 38 shocks of more or less intensity took place. At 10 p.m., loud rumbling was heard, followed by a final violent shock. Complete tranquillity then ensued; and on January 10th the police-authorities felt justified in requesting the inhabitants of Masaya, who had fled *en masse* to Granada, Tisma, Catarina, and other towns, to return to their homes.

The shocks were not propagated over any considerable distance, nor can the intensity have been very great, since no building was laid completely in ruins. The road from Masaya to the lake of the same name is bordered by crags of tuff, and so much débris crashed down from these that the road was completely blocked.

The Santiago volcano, which had been active since the summer of 1902, gave vent to no smoke or steam-cloud during the entire period of the earthquakes. It was not until January 9th that a smoke-pillar was observed rising from it again. It was reported, however, that at the time of the violent shock which took place at 1·30 p.m. on January 2nd, the parasitic cone of Pelon had opened up, and that smoke and gases had issued from a fissure therein. A Commission of Enquiry has since stated that a new crater had begun to form between the Santiago volcano and El Pelon, and that gases and steam were shooting forth from fissures exceeding 16 inches in width.

L. L. B.

CYPERACEÆ AND THE ACCUMULATION OF ALLUVIAL GOLD.

Le Cyperus tuberosus dans les Terrains aurifères de Madagascar. By H. JUMELLE *and* H. PERRIER DE LA BATHIE. *Comptes-rendus hebdomadaires des Séances*

[redacted]

that such conglomerates are the outcome of the deposition, by the agency of various micro-organisms, of the oxides of iron which partly make up the black sands, and that these micro-organisms are powerless to bring about such a deposition in running water, it will be observed that the requisite life-conditions and environment are found in the mud or slime which is retained during the dry season among the rootlets and rhizomes of the above-described *Cyperus*. This will, perhaps, explain also how ferruginous concretions often occur on the slopes of steeply inclined rocks, an impossible situation if mere deposition of iron in the ordinary way (without the intervention of bacterial agencies) is postulated. A further suggestion is made as to the possibility that certain species of bacteria may be capable of acting on gold and causing it to enter into combination with other substances; and one might then understand how it is that occasionally gold is found in the conglomerates in the non-free state.

L. L. B.

HUMUS AND THE FORMATION OF BOG- AND LAKE-ORES.

Die Bedeutung der wasserlöslichen Humusstoffe (Humussole) für die Bildung der See- und Sumpferze. By OSSIAN ASCHAN. *Zeitschrift für praktische Geologie*, 1907, *vol. xv.*, *pages* 56-62.

In Finland, the "country of the thousand lakes," the fresh water (with the exception of spring-water) is everywhere coloured by the humic substances held in solution therein, and it has been calculated that the Finnish rivers carry every year down to the Baltic 1,400,000 tons of such substances. In the same time they carry down about 1,750,000 tons of inorganic substances.

Careful analyses of the humic material derived from different river- and lake-waters in Finland show considerable variations in the percentage of carbon, hydrogen, nitrogen and oxygen, which are its principal constituents; but, considering how various in composition and origin are the substances from which the humic material is generated, there is nothing to give cause for surprise in this. Leaving nitrogen out of account, it may be of interest to note that the mean percentages indicate an approximation to the carbohydrates of the cellulose or amylaceous group. Bearing this in mind, and noting further the presence of nitrogenous and phosphorus-compounds, as also (all but invariably) sulphur in organic combination, the idea suggests itself that, under suitable conditions, the "humus sole" (as the author denotes the presumably colloidal solutions of humic material) may well serve as nutriment for certain lower organisms. It is surprising how little alteration this material undergoes, in the course of its journey of 250 miles or so from the Finnish lakes down to the Baltic; but once in the sea, it oxidizes with comparative rapidity—perhaps through the agency of certain forms of plankton. In fresh water, the determining factor in the assimilation of humic products by organisms is probably the simultaneous presence of certain metallic salts—chiefly those of calcium, magnesium and iron. In combination with the humic acids they form then humates. Now, the fresh waters of Finland, flowing over a predominantly granitic soil, are very poor in salts of lime and magnesia, wherein the sea-waters are rich; but there remain the possible humates of iron, and these in all probability play an important part in the formation of the lake- and bog-ores that are of such frequent occurrence in Finland.

It is a commonplace among geologists that the humic acids in the soil have much to do with the decomposition and leaching-out of rock-constituents. But these acids, of themselves insoluble, cannot fulfil their function unless they are, provisionally at least, taken up by water: in a word, the real decomposing agents are the "humus sols." The author agrees in the view that car-

bonic acid and ammonia, the terminal products of the simultaneous oxidation of the humic acids, also play a part in the chemical processes involved in the decomposition of the rock-constituents; but he adds, on his own behalf, the opinion that biological processes, initiated by certain lower organisms, form a necessary factor in this humic decomposition. He admits that the attempt to refer the formation of ordinary lake- and bog-iron-ores to the presence of soluble humic compounds has hardly gone as yet beyond the hypothetical stage; notwithstanding which he holds that there are many facts to be adduced in favour of the hypothesis, among them being the following:—When ferric and ferrous compounds in solution come into contact with "humus sols," a recombination takes place wherein chemical, and possibly physical forces as well, come into play. According to the conditions of concentration and to the presence of definite varieties of ions, after the ferrous compounds have been converted into ferric compounds by the agency of oxygen dissolved in water with the occasional co-operation of micro-organisms, precipitation of ferric humates takes place, or else they remain in solution. When completely dried at temperatures ranging from 212° to 230° Fahr., the soluble humic substances contain carbon, hydrogen, and oxygen in proportions that differ but slightly from those of the multimolecular carbohydrates, in addition to an average of 2 per cent. of nitrogen, some phosphorus, and sulphur in comparatively minute quantity. Consequently, as was above suggested, in the presence of basic substances this humic material would furnish an appropriate nutriment for lower organisms. In all probability, the ferrous and ferric humates, whether as precipitates or in solution, are the food of certain micro-organisms, and are by them decomposed into less complex compounds with the simultaneous liberation of iron in the form of a hydrated oxide. The organic carbon present in all the Finnish lake- and bog-iron-ores that have been examined occurs in the shape of remnants of humic substances, and so there appears to be no room for doubt that such substances play a considerable part in the formation of these ores. Further analyses of 21 samples of lake-ore and 11 of bog-ore, showed that they all contained humic acids, in proportions ranging roughly between 2 and 8 per cent. The very structure of the iron-ores (pisolites, oolites, etc.) points to the activity of micro-organisms in their formation.

Attention is directed, by the way, to the very common, and in some locali- [redacted]

of some 6 square miles), and in the neighbouring, intimately associated, Drammen granitite. Taking the Borvikdal as an example, a valley which has a maximum breadth of 300 feet, the ore-deposit in the valley-bottom overlies the ground-moraine (a sandy boulder-clay) and is in its turn overlain by peat to a thickness of 8 to 20 inches. The ore-body itself averages 2½ to 3½ feet in thickness, but sometimes thins down to 4 inches, and occasionally thickens out to 10 feet. It is evidently of post-Glacial age, and the plant-remains which are found in it show that it was forming after the migration of the pines (*Pinus sylvestris*) into the district. Whether deposition is still going on to a small extent is uncertain. The ore is extremely cavernous, and contains much hygroscopic water when freshly extracted. On drying, it for the most part crumbles away to powder. That portion of the ore-body which lies close to the solid rock (quartz-porphyry) that walls in the valley shows a curious inter-banding of blackish-brown manganese-ochre and brownish-yellow iron-ochre: the former ore being practically free from clayey particles, and the latter frequently full of them. Within a foot of the porphyry-wall there is perhaps more iron-ochre than manganese-ochre, the proportions becoming gradually interverted as one recedes from that wall, until some 60 feet away iron-ochre is scarcely present in any proportion worth mentioning. Analyses are given of the dried ore, the most interesting, perhaps, being that of an average commercial sample containing 41·2 per cent. of metallic manganese. Attempts have been made to work the Borvikdal deposit on an industrial scale, but so far only what may be called "samples" have been dug out, to the extent of 100 tons. The author estimates roughly the amount of manganiferous ochre in sight as equivalent to 10,000 tons of dried ore. Nearly all the fissures in the quartz-porphyry itself are filmed over with dendritic manganese, and in the neighbouring Drammen granitite at Myrsäteren the films become positively veins, to such a degree that a few years ago an attempt was made to work them opencast. Brief descriptions are given of the manganese ore-deposits of Flatdal in Telemarken; Idsö in the parish of Strand, district of Stavanger; and the southern part of Tysvär.

Expressly excluding from consideration the manganiferous nodules which are known to be forming at the present day in the abysmal depths of the ocean, the author proceeds to consider the relationship between iron and manganese in lacustrine and bog-ores. He quotes in this connexion several analyses, showing the gradations from an ore containing much iron and little manganese to one containing a great deal of manganese and scarcely any iron. In regard to Finnish ores, the rule seems universal that the lake-ores richest in manganese occur in soft ground where rushy growth flourishes, whereas the ores richest in iron are found on a hard or sandy bottom where reeds grow. Then, as to the relationship between iron, manganese, and the other heavy metals in the crust of the earth and in lake-and-bog ores respectively. In the earth's crust, the proportion of manganese to iron may be stated roughly as 1:50 or 60; and, although the difference seems enormous, it will be found that manganese is actually next to iron in order of abundance. In lake- and bog-ores the proportion is less startling: 1 of manganese corresponds to anything between 25 and 50 of iron; and this is only a very general average, Swedish and Finnish ores showing a much higher ratio of manganese. It may be observed that manganese possesses a higher solubility-tension than iron, on the whole, and is consequently taken up more easily than iron by the solutions which percolate through the rocks; the more so that manganese predominantly occurs in the silicates, from which it is released on weathering with somewhat greater facility than iron. Chromium, which comes next to manganese among the heavy metals in order of abundance, is extracted with difficulty by solution

from the rocks, and so it occurs in quite infinitesimal quantity in the manganiferous iron-ore deposits which are formed by hydrochemical processes.

Turning then to those sedimentary manganiferous deposits, the formation of which can be explained in the same way as the formation of manganese lake- and bog-ores, the author reckons among them the finest ore-deposits of the kind as yet known—namely, those of Kutais in the Caucasus and Nikopol on the Dnieper, the former being of Eocene and the latter of Oligocene age. It may be noted parenthetically that the Tertiary manganiferous deposits of Russia account for about one half of the entire manganese-output of the world. Genetically considered, all the known manganiferous occurrences can be classified into a series of groups; among these that which is of greatest industrial importance is the sedimentary group, more especially the division of lake- and bog-ores.

A section is devoted to the question of separate precipitation of compounds of iron and of manganese. This precipitation may be brought about by organic agencies, animal or vegetable; and also by what may be termed purely chemical processes. The latter, leaving metasomatic phenomena out of account, and considering only those that yield oxides and carbonates, result either (1) in neutral or reductive precipitation; or (2) in oxidic precipitation. Such ore-deposits as those of Glitrevand and the rich manganiferous lake-ores of Finland are the outcome of oxidic precipitation from solutions which were originally richer (by comparison) in iron and poorer in manganese than their precipitates.

In the next section, the reader's attention is called to the enrichment of metals, the distribution of which is otherwise comparatively limited, in manganiferous deposits. Postulating that, in the course of oxidic precipitation from solutions originally containing, besides iron and manganese, small quantities of nickel, cobalt, zinc, lead, copper, etc., the main mass of the iron is precipitated first of all, it follows that these rarer metals must concentrate together with the manganese in the residuum. And so it proves, in recent accumulations of lake- and bog-ores, that such metals do occur, even if that be in infinitesimal proportions; although the ratio is frequently much higher in manganese than in iron bog-ores. At Glitrevand, for instance, the latter contain 2 per cent. of zinc, and the ore of Golconda (Nevada) contains 2·78 per [redacted]

actual constituents, just as much as any other mineral, of the igneous magma, and he places in the same category those primary ores which have undergone local concentration or segregation in the magma by a process of natural metallurgy.

The author lays considerable stress on Mr. A. Gautier's theory, that the water belched forth by volcanoes is really derived from the deep-lying crystalline rocks, which, by reason of the increasing irregularity of the pressures to which they are subjected and the instability of the continuously-contracting crust of the earth, are folded, dislocated, and broken up. Their broken masses, coming into contact with the incandescent lava, are thereby sufficiently heated to lose their combined water. It has been shown that a cubic foot of granite heated to redness will lose about 0·85 ton of water or steam; hence, it may be inferred that the deep-lying crystalline rocks themselves contain enough water to feed all the mineral springs of which we have any cognizance. The water thus liberated acts upon the deep-lying rocks, producing in turn an enormous amount of various gases at high pressure, of the same composition as those collected from the fumaroles. All this sufficiently accounts for the tremendous power as well as the irregularity of volcanic outbursts. The connexion between these physico-chemical and hydrothermal phenomena and the succession of chloridic, sulphidic and carbidic fumaroles is shown. The successive formation of stanniferous, auriferous, plumbiferous and zinciferous ores, etc., followed by the evolution of carbonic acid bringing possibly with it iron and lime, appears to correspond to successive stages of cooling or to increasing remoteness from the eruptive magma.

The question of the determination of the age of a given ore-deposit is discussed, and the author points out in this connexion the fundamental distinction between the metals which are associated with acid, abundantly fumarolic, rocks and those which are associated with basic rocks. In the first group, the succession appears to be fairly constant, from gold and tin, accompanied by bismuth and tungsten, etc., in the form of chloro-fluorides at temperatures exceeding 932° Fahr.; through sulphides (700° to 550° Fahr.) of antimony, lead, zinc (with copper, iron and cobalt), silver and mercury (below 400° Fahr.); to iron, manganese, etc., as carbonates and possibly chlorides (below 212° Fahr.). Reasons are assigned for the difficulty which is encountered in attempting to determine the age of metals of the second or basic-rock group.

The author then gives a brief chronological synopsis, as it may perhaps best be described, of the various gold, silver, tin, copper, zinc, lead and iron-ore deposits of the world. He concludes with the rather obvious remark that metalliferous ores are to be found through practically the entire thickness of the earth's crust, in the oldest as in the most recent formations, and ore-deposits are forming nowadays, both seen and unseen. L. L. B.

DIFFUSION-THEORY OF THE ORIGIN OF ORE-DEPOSITS.

Bemerkungen zur Diffusion fester Metalle in feste kristallinische Gesteine. By G. B. Trener. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, 1905, *pages* 366-370.

At the periphery of the granite-mass of Cima d'Asta a whole series of ore-deposits occurs, and, in endeavouring to account for their distribution in space, the most obviously applicable explanation is that of magmatic differentiation. But this explanation would not hold good unaided, for the ores do not only occur at the contact-zone of the granite; they have penetrated deep into the schists which mantle it over. For such circumstances the modern teachings in regard to ore-deposits have so far failed to find an adequate physical explana-

tion; and so the author has endeavoured to solve the problem by pursuing another line of research, that is, by carrying out experiments in regard to the diffusion of solid metals or their oxides into solid crystalline rocks. These, he holds, prove that such diffusion is quite as possible as that of some metals into other metals. He points out that, so soon as the ores have accumulated by, let us say, magmatic differentiation at the contact-zone of the eruptive mass, they find a cool wall in front of them: the molecules will consequently invade the pores of the schist-mantle, and will fill up such fissures or cavities as they meet on their way. He is convinced that the phenomena of diffusion play a considerable part in many geological processes, and more especially in the genesis of ore-deposits; but he is very far from claiming that they are a universal factor, or from wishing to dethrone in their favour the many processes arising from chemical reactions. He admits, indeed, that many necessary limitations hedge round the diffusion-theory: for instance, the diffusion-coefficient of the various metals and ores; the temperature; the magnitude of the osmotic pressure; the porosity and permeability of the rock in regard to metals; not to speak of the influence of other agencies, such as the chemical reactions already mentioned, and even the stratigraphical conditions and mineralogical composition of the rock itself. In this connexion one of the results of his experiments is of especial interest: mica-flakes appear to oppose an insurmountable obstacle to diffusion, and so this can hardly take place at all in schists which include thick continuous bands of mica bedded at right angles to the direction of diffusion. L. L. B.

FORMATION OF IRON-ORE DEPOSITS AND THEIR CLASSIFICATION.

Über die Entstehung und Einteilung der Eisenerzlagerstätten. By O. STUTZER. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate,* **1906**, *vol. liv., Abhandlungen, pages* 301-304.

Whenever a basalt is examined under the microscope, it is found to contain well-developed octahedra of magnetite, which in some cases form accumulations considerable enough to be of industrial importance: thus, at Tåberg in Sweden accumulations of magnetite of this kind in a gabbro-massif form the object of mining operations, and similar titaniferous iron-ore deposits occur at [redacted]

in the course of 10,000 years, the thermal springs of the Laach Lake would form a deposit of iron-ochre 33 feet thick over an area of 14 square miles.

All the deposits to which reference has so far been made may be transported to another site by mechanical agencies, or leached out by chemical agencies, and re-deposited. The iron-ores of Salzgitter and Dörnten, north of Goslar, are a good example of purely mechanical redeposition: angular and rounded fragments of brown hæmatite occur there, bound together by a ferruginous cement. The ores are shown to have originated in Jurassic times, and to have been redeposited in the Cretaceous period. Chemical redeposition, of which the limonites and bog iron-ores are salient examples, is of much more frequent occurrence; and there seems to be little doubt that, in former geological periods at all events, iron-ore deposits have been formed at the bottom of the sea, such as those of Cleveland and Lorraine, Kressenberg and Hildesheim.

Nor must the leaching action exerted by springs flowing through rocks rich in iron be forgotten, precipitating later on the iron which they have thus leached out of the rocks, although originally the springs themselves contained no ferruginous particles. Ochreous deposits formed in this manner are to be seen in the Bunter Sandstone district of the Black Forest.

All the iron deposits enumerated above are subject to modification and metamorphosis through the phenomena of tectonic movement (pressure, etc.), decomposition and weathering; and thus it is not always easy to solve the problem of their primary genesis. The following classification is suggested: (1) Primary deposits, including (*a*) magmatic differentiates; (*b*) magmatic lodes; (*c*) pneumatolytic-hydratogenous (contact-deposits); and (*d*) deposits formed from thermal springs. (2) Secondary deposits, including (*a*) those formed by mechanical redeposition; and (*b*) those formed by chemical leaching-out and redeposition. L. L. B.

MAGMATIC SEGREGATION OF IRON-ORES IN GRANITE.

Über magmatische Ausscheidungen von Eisenerz im Granit. By J. H. L. VOGT. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 86-89, *with* 5 *figures in the text.*

The author can only explain satisfactorily to himself the occurrence of deposits of magnetite in several localities in the extensive granite-area of the Lofoten isles, in Northern Norway, on the hypothesis that they are the outcome of a process of magmatic segregation within the granitic magma.

The Lofoten granite, belonging to the fundamental rock-group, is frequently porphyritic, the phenocrysts being orthoclase or microcline; the ferromagnesian silicates are developed in it, either in the form of biotite, or in that of hornblende, and sometimes of both minerals; basic segregates of amphibolite are of frequent occurrence; the silica-percentage averages 70; and, finally, the granite sometimes shows signs of intense compression and sometimes of very little.

At Fiskefjord and in its neighbourhood, on the island of Hindö, within a belt some 6½ miles long and 2 to 2½ miles broad, there are several hundred distinct magnetite-deposits (reckoning in those of insignificant extent as well as those of some importance). Some 30 miles farther south-west, on Westvaagö and Gimsö, within a belt some 3 miles long and 2 miles broad, there are at least twenty such deposits—a number that could be easily increased to fifty, if small ore-bodies a couple of feet or so in length were included. And these are not the only iron-ore belts within the Lofoten granite-area. They may be generally described as flattish lenticular masses, which occasionally

exceed 820 feet in length and 115 feet in breadth, but are generally of smaller dimensions; and by far the greater number range from 30 feet or thereabouts to 80 feet in length, with a breadth of a couple of yards or so. The bedding-planes of these ore-bodies are sensibly parallel with the structural planes of the enveloping granite.

Morphologically, the iron-ores here described are comparable with the segregations of titaniferous iron-ore in gabbros, labradorite-rocks, augitic and nephelinic syenites, etc.; as also with those of chromite in peridotites, especially in those cases where these rocks have undergone great compression.

In the immediate vicinity of the ore-bodies, the Lofoten granite is markedly rich in magnetite, biotite and hornblende. Although the iron-ore is almost exclusively magnetite, the deposits are of variable mineralogical composition. Thus, in the Fiskefjord area, the magnetite is so commingled with quartz, hornblende, biotite and sometimes garnet, that the crude ore averages only from 35 to 38 per cent. of metallic iron. The ore is here of a highly-schistose structure, resembling in appearance the *torrsten* or hard ore of Sweden. In the Smorten-Jörendal area (Westvaagö and Gimsö), the associates of the magnetite are predominantly hornblende, biotite and pyroxene—quartz and felspar being of sparse occurrence; hereabouts the ore averages 40 to 60 per cent. of metallic iron, and schistose structure is but feebly (if at all) apparent. In other portions of the great Lofoten granite-area geologically similar ore-deposits have been found, averaging from 60 to 65 per cent. of metallic iron. As a rule, some pyrites, and occasionally magnetic pyrites as well, is associated in varying quantity with the magnetite. Apatite is also of variable occurrence: in the Fiskefjord district, the percentage of phosphorus averages 0·2, but is sometimes higher. In one hole, the author saw an apatitic iron-ore, with macroscopically visible apatite, somewhat resembling the Gellivaara ore. In other districts, however, as, for example, Smorten-Jörendal, the percentage of phosphorus in the ore is quite insignificant (0·03 to 0·05). The granitic pegmatite-veins which frequently seam the Lofoten granite are also observed to strike through the ore-bodies.

There is no doubt that these iron-ores were formed at the time of the eruption of the granite, and that they accumulated within the granitic magma by some process of magmatic segregation or differentiation. Perhaps the same [redacted]

mineralized with salts of iron and salts of aluminium. That is why limonite is always associated with the bauxite which retains the form of oolite after the dissolution of all the iron (that is, by hydrochloric acid).

In the course of his numerous experiments, the author has endeavoured to reproduce the varying particularities of epigenetic phenomena, and he is thus enabled to explain why the deposition of iron does not always take place in a perfectly even manner throughout the entire limestone-mass. The slightest variation in structure is sufficient to cause the ferruginous solutions to flow by certain points without yielding any precipitate, while near by they may be throwing down great quantities of iron. The difference in volume between limonitic oolites and calcareous oolites within strata of the same age is dependent on the difference in density of the two substances; so, too, the flattened form of the ferruginous oolitic granules contrasts with the sphericity of the granules in oolitic limestones.

But the history of the pisolitic iron-ores is only a particular case from among the numerous instances of the change of a calcareous formation into a ferruginous one, and in all these instances the chief structural features have been preserved despite the fundamental alteration in composition. These facts bear eloquent testimony to the unceasing activity of aqueous solutions circulating in the subterranean regions of the earth's crust. L. L. B.

STRATIGRAPHICAL CONDITIONS AFFECTING THE OCCURRENCE OF PETROLEUM.

Einiges über die Lagerungsverhältnisse des Erdöls. By A. F. STAHL. *Chemiker-zeitung*, **1906**, *vol. xxx., No.* 30, 4 *pages*.

Premising that it is well-known that the largest quantities of petroleum are obtained from the summits of anticlinal folds, where the oil, saturated with gases, is often present in such abundance that it must have been stored up and concentrated, and cannot possibly have originated where it now occurs, the author maintains that it must have formed in the practically horizontal beds of widespread basins, where consequently it was originally distributed over a very extensive area. In such beds, wherein we cannot hope to find either locally great accumulations of petroleum or high tension of gases, bore-holes or sinkings could only meet with scant success. Moreover, the necessity of getting through a great thickness of barren strata, which generally overlie the productive oil-bearing beds, has to be taken into account. It may be postulated that orographic movements, that is, folding of portions of the earth's crust, originated the concentration or accumulation of petroleum. But such movements involved also the bursting up and fissuring of the barren strata, whereby a path was opened to the influence of atmospheric agencies, the final result being that the productive oil-bearing horizons were brought nearer to the surface and rendered more accessible to boring operations.

The author distinguishes, however, between two systems of tectonic plication. With the first, the true orographic or mountain-building folds, are associated merely sporadic petroleum-deposits, the industrial value of which is, to say the least, doubtful. But, with regard to the second, examples of which are patent in the Caucasus and in Persia, where several ranges of foot-hills strike parallel with the great mountain-chains, the case is different. He explains how each elevation here above the average level of the anticlines received an elliptical form, and constituted thereby an eligible reservoir for petroleum. In the course of being folded up into anticlines every kind of rock, except the plastic clays, was inevitably cleft and fissured, such clefts and fissures favouring, of course, the accumulation of oil; and so it often happens

that a bore-hole which luckily penetrates a fissure proves very productive, while another put down close by, but missing the cleft, fails to strike oil at the very same horizon.

Plastic clays are an essential factor in the productivity of petroleum-bearing beds, since they form a hermetic seal closing up the natural reservoirs of oil and gas: they neither allow the latter to escape, nor do they permit the access to them of the destructive agencies of the atmosphere. And thus it is that, where the anticlines are acutely folded, and the strata have been so fissured as to cleave the argillaceous horizons also, little reliance can be placed on either the quantity or the quality of the petroleum that is to be got there.

As to synclinal folds, the author avers that only in exceptional cases could we hope to find productive oil-reservoirs therein. The laws of gravity, remembering that petroleum is generally associated with natural brine, forbid.

In conclusion, it is pointed out that where marls and shales predominate, while conglomerates and sands, if present at all, play a very subordinate part, petroleum of excellent quality, though perhaps in small quantity, may be found.

L. L. B.

TERTIARY COAL-DEPOSITS OF RUDA, DALMATIA.

Das kohlenführende Paläogen von Ruda in Mitteldalmatien. *By* F. VON KERNER. *Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt*, **1907**, *pages* 134-157, *with* 3 *figures in the text.*

Stratigraphical evidence is adduced to show that the utmost extent of the coal-seam of Ruda, in Central Dalmatia, along the strike cannot exceed a mile; and stress is laid upon this point, because in non-geological circles the expectation had been (and perhaps is still) cherished that the seam would be found to extend far eastwards into the foot-hills of the Prolog range and equally far westwards to the margin of the Sinjsko Polje. This delusion has been fostered by the discovery, below the summit of Mount Varda, of a black, combustible, mineral substance which has some external resemblance to the Ruda shaly coal; it is probably, however, a peculiar form of the highly bituminous infiltrations which are locally not uncommon in the Cretaceous limestones of Dalmatia. As to the presumed westward extension, the lignites of [redacted]

The purest black coal from the seam burns well in an open grate, leaving but few cinders; in the process of burning it becomes remarkably soft and coking, and various expert opinions concur in pronouncing it to be a mineral peculiarly suitable for the purposes of gas-manufacture. An officially conducted analysis in Vienna of the dark-grey so-called "coal-shale" (the less pure portion of the seam) yielded the following results: a sample burnt in the open grate left 34·4 per cent. of ash, and the heating capacity amounted to 3,065 calories; a sample submitted to gasification yielded 4 per cent. of hygroscopic water, 45 per cent. of heavy hydrocarbon gases, and 51 per cent. of residues.

The Ruda valley, a narrow glen terminating in a great circular expansion, is the outcome of longitudinal and cross-faulting, and is filled with strata of later age and of easier erosion than the rocks (Cretaceous limestones and dolomites) which hem it in. The younger strata are assignable to the Eocene and early Oligocene divisions of the Tertiary system, and, consisting largely of limestones, limestone-conglomerates and flaggy calcareous marls, may be separated into three groups, at the base of the uppermost of which lies the coal-seam. This rests upon a marly, much-fissured limestone, full of *Chara*-seeds and fossil freshwater mollusca. The seam, taken as a whole, is several feet thick, but consists of various bands of pure black coal and dark-grey coal-shale separated by marly partings. The immediate roof is a thinly flaggy, marly limestone, wherein fragments of the branches of a fossil conifer (*Araucarites*) and impressions of leaves (such as *Dryandra*) are of tolerably frequent occurrence. This roof, which is bereft of even a trace of coal, is overlain by a lithologically similar stratum with which, however, are interbedded several venules of coal-shale each barely an inch thick. The Ruda coal-flora includes twenty-three species of definitely-determined plants, and perhaps another score the attribution of which is uncertain: it points to the late Eocene or early Oligocene age of the beds; and the probability is, that in this region the Tertiary floras were slower to change than the corresponding faunas.

The tectonic structure and the stratigraphy of the Ruda valley are described at considerable length, this description forming perhaps the greater bulk of the paper. L. L. B.

CARBONIFEROUS MARINE STRATA IN HUNGARY.

Das Marine Karbon in Ungarn. *By* Fritz Frech. *Földtani Közlöny,* **1906**, *vol. xxxvi., pages* 103-154, *with* 3 *figures in the text and* 9 *plates.*

The author describes and figures, first of all, three species of brachiopods and two of corals from Kornyaréva in southern Hungary, the only locality in the southern Carpathians where Lower Carboniferous rocks are so far known to occur. He then proceeds to describe and (in most cases) figure fourteen species of brachiopods, four of lamellibranchs, seven of gasteropods, three of trilobites and two of corals, from the Nœtsch beds of Dobsina or Dobschau, remarking by the way that the material is mostly in a very bad state of preservation. He assigns the age of the Kornyaréva beds to the upper division of the Lower Carboniferous (Viséen); with regard to the Dobsina rocks, which also belong to that upper division, he shows what forms are common to the Nœtsch beds and to those of Carinthia and Styria, and also what forms are common to the Lower Carboniferous of Silesia. Except for the occurrence of cephalopods in the last-named province, the character of the faunas, as well as the lithology of the rocks, indicates in all these cases deposition in comparatively shallow waters. A further comparison is made with the Lower Carboniferous of Sarayevo in Bosnia and with that of Asia.

In conclusion, the author points out that, hitherto, no fossils of Lower

Carboniferous age had been definitely determined from Hungary, or from the southern and eastern districts of the Balkanic peninsula. The Kornyaréva and Dobsina beds are the oldest fossiliferous deposits in the Carpathian region of Hungary, and to their occurrence attaches an interesting possibility: namely, that somewhere in this region, amid the folds of the older Palæozoic strata, plicated in Carboniferous times, a mass of productive Coal-measures lies hidden away under a cover of younger sediments. This would approximate to what is the normal condition of things in the Carboniferous areas of Central and Western Europe. L. L. B.

PETROLEUM-BEARING ROCKS OF KOMARNIK-MIKOVA AND LUH, HUNGARY.

Über die Petroleumvorkommen von Komarnik-Mikova und Luh. By JULIUS NOTH. *Földtani Közlöny*, **1907**, *vol. xxxvii., pages* **99-104**, *with a map and section in the text.*

In three of the ranges of hills belonging to the Carpathian mountain-system, which strike across the frontier southward from Galicia into Hungary, the occurrence of pertoleum has now been definitely proved. At Körösmezö, in Máramaros county, the conditions of the occurrence differ in some respects from those observed in the Galician deposits; but at Luh and Komarnik-Mikova in the neighbouring counties, the similarity with Galician conditions is unmistakable, as regards both the tectonic features and the lithological composition of the oil-bearing rocks. Sandstones of Cretaceous age rich in calcite, are followed by red and mottled fucoidal marls, and these again by Nummulitic calcareous sandstones. In the north-east of the area described, mottled clays overlie fine-grained sandstones strongly impregnated with oil; upon them rest greenish and bluish fucoid-beds and finally Menilite-slates, which in places have a capping of Magura sandstone. The range of hills constituting the oil-belt and consisting of the rocks just described is traceable from Polany, through Ropianka and Barwinek (all well-known Galician localities), south-eastward across the Hungarian border to beyond Komarnik. The place where oil was struck at Barwinek is hardly 1¼ miles distant from the Hungarian border, which is there a gently-sloping divide or watershed some 1,650 feet above sea-level. At Mikova, 18¼ miles within Hungarian territory, several [redacted]

and it is in these, rather than in the Menilite-slates, that boring operations are likely to prove fruitful. For, if all the oil hitherto struck at Luh is really associated with the Menilite-slates, payable quantities are not to be expected, as such petroleum as those beds contain is mere leakage from the older (Eocene) red marls, etc. L. L. B.

PETROLEUM- AND OZOKERITE-DEPOSITS OF BORYSLAW, GALICIA.

Boryslaw: une Monographie géologique. By J. GRZYBOWSKI. *Bulletin International de l'Académie des Sciences de Cracovie,* 1907, *pages* 87-124 *and* 2 *plates.*

Natural exposures in the oil-bearing and ozokerite-belt around Boryslaw are so scarce, that, in order to gain a real insight into the tectonic structure of that supremely interesting district, geologists have to pursue their investigations along a considerable extent of the marginal zone of the Carpathians. Some of the best exposures are seen in the Nahujowice valley, 5 miles to the west, also in the Jasienica, Popiele and Tyśmienica valleys, and near Tustanowice and Truskawiec. The strata are briefly described, and appear to consist chiefly of an alternation of soft glauconitic sandstones, with brown and grey shales and clays and occasional conglomerates.

The entire second chapter of the memoir is devoted to the stratigraphy of the marginal zone of the Carpathians, and the author tabulates the rock-succession at Boryslaw as follows, his conclusions being strengthened by recent fossil-finds:—The highly-contorted *Inoceramus*-beds (Ropianka beds) of Upper Cretaceous age are overlain by massive Jamna sandstones (possibly Cretaceous, but more probably Eocene). To these succeed the Hieroglyphic sandstones (among which are intercalated thin bands of red and grey clay) and sandy marl-slates of undoubted Eocene age; upon which follow the Menilite-slates (the lower portion of these being very cherty) and the Dobrotow sandstones and shales of Lower Oligocene age. Then follows an unconformity, the entire series being capped by the Miocene saline clays (first Mediterranean stage). The ozokerite-deposits now worked occur in the Dobrotow group. There is a grey, slightly marly, unbedded shaly material known as *zytyca*, which in the north-eastern area of the ozokerite-workings, goes down to depths of 170 and 200 feet; its petrographical characters assimilate it to the ejectamenta of many mud-volcanoes, and in all probability it is in fact the product of long-extinct mud-volcanoes which must have been active at some epoch previous to the last orographic movements to which the region has been subjected.

The ozokerite-veins generally have a steep dip, and their limiting-surfaces, especially at the foot-wall, are smooth and black as if varnished. The infilling consists of fragments of the country-rock with which the ozokerite is intermingled; although the latter often occurs independently in big lumps, and tends indeed to accumulate at either wall of the vein. Crystals of rock-salt are frequently associated with it. The author distinguishes between (*a*) simple and (*b*) compound veins. The former are generally of no great thickness, while the latter in groups of thin parallel veins often attain a thickness of 100 feet or so. Occasionally the veins bifurcate, and on passing, say, from a tough into a soft rock-formation they may be seen to form stringers and secondary or lateral veins. These stringers, forming layers of pure ozokerite along the bedding-planes some feet distant from the principal vein, are termed by the Boryslaw miners *plazowka* or flat veins. According to the strike, the veins may also be classified as longitudinal and transverse veins respectively,

the former striking almost parallel with the country-rock, and the others almost perpendicular thereto. The principal longitudinal vein now worked dips 65 degrees northward, strikes between west-north-west and west, thins out and becomes impoverished towards the south-east while it broadens out and becomes richer towards the north-west. It is cut across by several transverse veins, some of which are of considerable importance. The veins are evidently the infilling of fissures opened up in a highly dislocated mass of strata.

The petroleum-deposits so far explored in this district extend over a length of 1¾ miles (not including Tustanowice) from north-west to south-east, and over a breadth of little short of a mile. The productive oil-field is cut off on the north-west by the Ratoczyna valley, beyond which the oil-bearing strata (but no appreciable quantity of oil) have been struck in various borings. The north-eastern and south-eastern boundaries of the oil-field have been determined with some precision, but its south-western limit (towards the mountains) has not yet been definitely ascertained. The strata pierced through by the bore-holes, details of fifteen of which are tabulated, are predominantly grey and brown shales alternating with grey to greenish fine-grained sandstones, with occasional bands of conglomerate. Basing his conclusions on the results, however, of no less than 160 borings, the author points out that the principal oil-horizon (petroliferous sandstone) occurs among or below the deeper-lying black-shales of the Dobrotow group. This horizon dips towards the middle of the field some 20 degrees southward, from a depth of (say) 2,000 feet below the surface to 2,600 feet or more; and farther south it suddenly drops to a depth of 3,300 feet, but still farther south again is struck at somewhat shallower depths. Several oil-horizons of variable productiveness are recognized at Boryslaw above this principal one, this variability having probably something to do with the fissuring of the strata to which reference has already been made. It may be added that the author agrees with the view that the ozokerite was originally derived from the petroleum.

The fifth chapter deals mainly with the tectonics of the area, a study of which leads to the following inferences: (*a*) that bore-holes put down farther south, at all events within the area of the Hieroglyphic sandstones, may possibly reach at greater depths the Boryslaw oil-bearing beds; and (*b*) if Menilitic cherts are struck, which is to be expected in the course of boring for the deep-

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porphyry and granodiorite are intruded into this diabase (which covers a vast area) at many localities, including the mine itself. The granodiorite is quarried for building-stone, and dykes of it traverse a gabbro which also occurs in the neighbourhood of the mine.

At the Miklós shaft, in the Tataroja valley, upstream from Kazanesd, lodes of copper-ore 12 to 16 inches thick, striking east and west, are known to occur, and in the immediate vicinity are traces of ancient workings where the author, however, found only very thin metalliferous lodes.

The question as to whether the gabbro above mentioned is a dyke-rock or a deep-seated eruptive is of more importance than would at first sight appear. Dr. Karl von Papp inclines to the latter view, and the author agrees with him; but Mr. Messena held that the gabbro had broken through the diabase in dyke-like masses, followed at later periods by the quartz-porphyry, and finally by the granodiorite. Admitting that the diabase dates from Triassic time, the gabbro would then have been erupted in company with the melaphyres in the Jurassic period, the quartz-porphyry in the Cretaceous, and the granodiorite in the latest Cretaceous or more probably the Tertiary period. And, as a consequence, the metalliferous ores would date from several different periods.

The author adduces reasons, however, for considering that the gabbro is really the oldest rock in the area, and that it was succeeded by the diabase. The great masses of pyrites mined at Kazanesd are possibly of magmatic origin; but the action of the quartz-porphyry eruptions had in all probability much to do with the formation of the ores there, as also in the cupriferous lodes, which are quite distinct from the stockworks of pyrites. Such lodes traverse both the gabbro and the diabase (although containing but little ore in the latter), and are probably the infilling of fissures which were opened up in the rocks at the time of the diabase-eruptions or perhaps even later.

Some 600 feet away from the mining settlement, the Petrosza valley branches off from the Tataroja valley, and here recent railway-cuttings have exposed the diabase and a quartz-porphyry dyke veined with pyrites; in all probability, this is the very same dyke that is fonud to be cupriferous in the Pozsorit mines in a neighbouring valley, and it strikes therefore right across from one to the other. In the Kaprilor valley, parallel with that of Tataroja, copper-ores were at one time actively worked in rocks similar to those above described, but, owing to insufficient output, mining operations have now been suspended there. The cupriferous lodes in the gabbro-area of Almasel are geologically similar to the occurrences in the Kaprilor valley, and have been opened up by a French company. It is found that there the lodes become richer in depth, and thus it seems possible that the Kaprilor lodes also might yet repay working; but the cost of further exploration-work would be heavy.

L. L. B.

COPPER-ORES AND WOLFRAM-ORES IN SOUTHERN TYROL.

Ueber das Vorkommen von Kupfererzen und Scheelit im Eruptivgestein von Predazzo und anderen Orten. By J. Block. *Sitzungsberichte der Niederrheinischen Gesellschaft für Natur- und Heilkunde zu Bonn*, **1905**, *pages* A68-A82.

The neighbourhood of Predazzo was, at some period later than the Trias, a centre of vulcanicity to which the granites, porphyrites, melaphyres and monzonites of Monte Mulatto (7,055 feet) bear eloquent testimony. On this mountain, as on Monte Malgola, which towers above Predazzo to the south-east, copper- and iron-pyrites and magnetite occur in considerable quantity. The last mentioned ore was at one time worked on the eastern flank of Monte

Mulatto, at an altitude of 5,170 feet. On the northern flank of the same mountain, from the height of 5,250 feet up to the summit much exploration-work appears to have been attempted in the chalcopyrite-deposits. The Bedovina mine on the western flank has been opened up in a shatter-belt of melaphyre (5 feet broad) consisting of narrow fissure-veins, some of which are parallel one to the other, while others intersect. These veins are mineralized with chalcopyrite, iron-pyrites, some malachite, scheelite (tungsten), etc. The wolfram-ore is again noted, amid stellate aggregates of tourmaline associated with fluorspar, in the tourmaline-granite quarries upstream from Predazzo, on the right bank of the Avisio. A rare associate is arsenical pyrites. The scheelite is of coarse texture, presents a greasy lustre, and a pale pea-yellow colour. There appears to be no question of the genetic analogy between those Monte-Mulatto ores and tinstone or cassiterite-veins. The copper-ores, just as those of Rammelsberg and Rio Tinto, average 2 to 3 per cent. of metallic copper; but the association of scheelite with them (as at Monte Mulatto) is an uncommon occurrence, and is of some industrial importance. Remembering that the metals of the wolfram- and vanadium-groups generally concentrate in acidic eruptive magmas, we may perhaps invoke the conjunction of acidic and basic eruptives in the district here described, as furnishing in part the explanation of so rare an association.

The marbles and serpentine-rock of the district are described at some length. L. L. B.

FORMATION OF THE BELGIAN COAL-MEASURES.

Observations paléontologiques sur le Mode de Formation du Terrain houiller belge. By A. Renier. *Annales de la Société géologique de Belgique*, **1905**, *vol. xxxii., Mémoires, pages* 261-314, *with* 11 *figures in the text and* 1 *plate.*

In the first chapter the author discusses the significance of the terms "roof" and "floor" in relation to coal-seams, and points out that the miner is more apt to differentiate the roof from the floor by their respective lithological and palæobotanical characters than by their stratigraphical position. Yet it is manifest that here stratigraphy plays quite as important a part as lithology and palæontology. Generally speaking, the roof is characterized by the absence of *Stigmaria* (except as débris) the rootlets of which usually occur entire [redacted]

in every case, been necessarily floated from any great distance; while he regards the entire *Stigmaria* as having undergone fossilization at the spot where they grew, and therefore that the floor originally constituted in every case a vegetable soil (or plane of plant-growth, if that term be permissible). The fact that the appendices of the *Stigmaria* are often directed obliquely or vertically upwards as well as downwards leads him to suggest that they penetrated after the fashion of rhizomes into a mud that had already been laid down.

There is another aspect of the question, to which so far little attention seems to have been devoted. The author figures and describes in detail instances of the penetration by the rootlets of *Stigmaria* of those disintegrated plant-remains which are known to occur in the roofs of coal-seams. He arrives at the conclusion that all barren strata in the Coal-measures are "roof"; consequently, that the roof as thus defined has no special mineralogical nor any essential palæontological characteristic, although it often contains disintegrated plant-remains. When it has been transformed by the superimposition or implantation within it of vegetation (chiefly *Stigmaria*) it becomes a floor. Wherefore a floor may contain the fossil impressions supposedly characteristic of a roof, since it is in many cases nought but an altered roof; and, for the same reason, a "floor" may become the roof of a coal-seam, but only when the parting between it and the next seam is inferior in thickness to the transformed layer or stratum.

The second chapter is devoted to the investigation of the occurrence of more or less erect trunks of fossil trees in the Belgian Coal-measures. Fresh discoveries of these have been accumulating within recent years, but they do not always furnish incontrovertible proof of vegetation *in situ*, since it has been shown that drift-wood may occur in an erect position within the sedimentary deposits. The finer grained and the more clayey is the sediment at the base of such a trunk, the greater is the chance that the tree grew where we now find it; but this opinion is almost converted into certainty if a number of delicate rootlets are observed in undoubted connexion with the trunk. The difficulty of ascertaining this in every case, however, impels us to cast about for other accessory proofs. One has, of course, to be on one's guard against the possibility that a trunk with roots and all has been washed bodily away from its original habitat. Indeed, most Belgian geologists who have described the erect trunks found in their Coal-measures are, to judge from the passages quoted in this chapter, inclined to disbelieve in the trees having grown where they now occur; but the author argues with great persistence and plausibility against the drift-wood theory in almost every case.

In his third chapter, he begins with the statement that the formation of the Coal-measures is the result of the repetition of the cycle:—floor, coal-seam, roof, . . . floor, except perhaps in the case of certain cannel-coals. He regards an ordinary coal-seam as the result of the putrefaction in place and under water of several varieties of plants, and probably (though in a smaller proportion) of some animal organisms. The hypothesis that coal-seams have been built up by the continuous superimposition of forests on deposits which were in process of conversion into peat, does not exclude the probability that some of the constituents were drifted. In fact, the occurrence of rolled pebbles actually within the coal, proves that there must have been drifted vegetable material which by its comparative lightness could act as the carrier of these pebbles. It seems probable that the area wherein the Belgian Coal-measures were being deposited was at that time physiographically featureless; and, in this connexion, it may be recollected that palæobotanists have shown that

Stigmaria could not have flourished under a greater depth of water than 16 feet or thereabouts.

A bibliographical list consisting of twenty-nine entries is appended to this very exhaustive paper. L. L. B.

A MARINE BAND IN THE CHARLEROI COAL-MEASURES, BELGIUM.

Découverte, dans le Terrain houiller supérieur de Charleroi, d'un nouvel Horizon fossilifère marin (le plus élevé). By RENÉ CAMBIER. *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie,* 1906, *vol. xx., Procès-verbaux, pages* 169-171.

Prof. X. Stainier, in his great monograph on the Coal-measures of Charleroi and the Lower Sambre, had cited, as the uppermost band containing a distinctly pelagic fauna, an horizon some 100 feet above the roof of the Sainte-Barbe seam of Floriffoux, yielding *Lingula mytiloides* and scales of *Elonichthys*. Recently, however, the author has found *Lingula mytiloides* in No. 12 pit of the Charbonnages Réunis, at Charleroi, about 20 feet below the Duchesse or Naye-à-Bois seam; that is, 1,476 feet above the highest horizon at which that *Lingula* had been hitherto recorded in the Charleroi basin.

The floor of the Duchesse seam is, at this locality, rather gritty in character; it passes downward very gradually into a sandy shale; thence into a grey shale; and finally into a very characteristic grey-striped black shale, which breaks up into long parallelipipeds and is more or less regularly interbanded with thin clay-ironstones. *Lingula mytiloides* occurs in great abundance in this shale, in two varieties, the smaller and most abundant of which exhibits some resemblance with *Lingula parallela* of Prof. John Phillips. Throughout the entire thickness of the shale, but more especially near the bottom and near the top, *Carbonicola subrotunda* is found. A fish-scale has been obtained, belonging apparently to the genus *Rhizodopsis*. Some vegetable débris, much comminuted, also occur; they are, very evidently, drifted material.

This newly-discovered marine-band facilitates the correlation of the Liége Coal-measures with those of Charleroi, and constitutes another presumption in favour of the contemporaneity of the two basins. L. L. B.

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species of fishes, cephalopods, lamellibranchs, brachiopods, etc., have been identified, and permit of the correlation of these barren beds with the Pendleside series of British geologists (placed by Dr. Wheelton Hind at the base of the Lancashire Coal-measures, below the Millstone Grit). The specimens of *Posidoniella* at Baudour are remarkably abundant, encrusting the shaly layers in myriads; occasionally they are massed together on plant-remains or on the tests of Orthocerata.

(2) *Sur la Flore du Terrain houiller inférieur de Baudour (Hainaut). By* ARMAND RENIER. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 736-738.

The flora of this barren group was but little known hitherto, and the collections made at Baudour have enabled Mr. Renier to draw up a list of 39 undoubted species of plants, to which he expects to add at least a dozen others ere long. These include a great number of ferns, also several species of *Lepidodendron, Calamites, Rhabdocarpus, Trigonocarpus*, etc. Westphalian forms are comparatively rare in this flora, the main features of which are characteristic of the Culm ('Primäre Carbonflora' of Dr. H. Potonié). It is a flora which is certainly much older than that of Zone A (established by Prof. R. Zeiller in the Valenciennes coal-basin) and is easily distinguishable from it, a point which the author holds to be of great practical importance.

L. L. B.

LOWER DIVISION OF THE LIÉGE COAL-MEASURES, BELGIUM.

Note sur la Zone inférieure du Terrain Houiller de Liége. By P. FOURMARIER. *Annales de la Société géologique de Belgique*, 1906, *vol. xxxiii., Mémoires, pages* 17-20 *and a table.*

The author separates the Liége Coal-measures into two great divisions, the lower of which is characterized by the absence, or, at all events, the great scarcity of any forms of *Neuropteris* other than *Neuropteris Schlehani* of Stur, and by the presence of a zone of *Sphenopteris Hœninghausi* near the top. The upper division, on the other hand, is characterized by the abundance of other forms of *Neuropteris* than *Neuropteris Schlehani*, as, for example, *Neuropteris gigantea, Neuropteris heterophylla, Neuropteris obliqua, Neuropteris flexuosa*, with *Neuropteris tenuifolia* and *Neuropteris rarinervis* near the top. He has now been enabled, by the discovery at the Six-Bonniers colliery in the Seraing district, of a band with big nodules containing undoubtedly marine fossils (*Goniatites* and *Lingula mytiloides*) to correlate these measures with those of the Herve basin, where a similar marine band, full of nodules containing *Gastrioceras Listeri, Pterinopecten* and *Orthoceras*, is known to occur. Taking the marine band in each case as the starting-point, the succession of the strata is remarkably similar in the Seraing and Herve districts. But the author goes further than this, and assimilates tentatively the succession at Herstal with that just mentioned. He points out, however, that in certain parts of the Liége coal-field, there is so much variation, both in the composition and in the succession of the coal-seams, that he would be a bold man who would claim to trace every seam and venule throughout the basin.

In his table, therefore, the author does not wish to indicate absolute synonimity of the strata, but to compare synchronous horizons, this being the most important matter for the mining engineer, whose chief desire must be to know whether there is still a great thickness of Coal-measures below the seams that he is working. L. L. B.

MARINE BANDS IN THE UPPER COAL-MEASURES OF MONS, BELGIUM.

Note sur des Lits à Fossiles marins rencontrés dans le Houiller supérieur (H_2) *au Charbonnage du Nord-du-Flénu, à Ghlin.* By J. CORNET. *Annales de la Société géologique de Belgique*, **1906**, *vol. xxxiii., Mémoires, pages* 35-39.

A drift lately started in a northerly direction, at the 1,690 feet level of the Nord-du-Flénu colliery at Ghlin, has penetrated a hitherto completely unknown portion of the *couchant de Mons* coal-basin. Here, at two horizons, 28 feet apart, such well-known brachiopods have been found as *Spirifer bisulcatus* and *Productus carbonarius*. The uppermost horizon is in a greyish-blue, soft, unaltered shale of fine texture, of the ordinary type of Coal-measure shale. In addition to the brachiopods already mentioned, it has yielded *Orthis resupinata*, *Athyris planosulcata*, *Pterinopecten papyraceus*, and *Lingula* (?). It overlies a crushed carbonaceous shale with irregular venules of coal (a pinched-out coal-seam?), about 2 feet thick; the greyish-blue shale above-mentioned has a thickness of 30 feet, and the marine band occurs near the base of it. The lower horizon is in a greyish-blue to black, somewhat altered shale, of coarse texture and varying toughness, slightly over 2½ feet thick, and has yielded *Chonetes laguessiana*, besides the two brachiopods first mentioned. Generally speaking, all these fossils are in good preservation, uncrushed, and easily determinable.

The stratigraphical equivalent of these marine bands (high above the Coal-measure conglomerate) would be the roof of the Sainte-Barbe seam of Floriffoux (No. 61 horizon of Prof. X. Stainier), although their fauna recalls that found by Messrs. C. Blanchard and J. Smeysters, at the Forte-Taille colliery, below the Coal-measure conglomerate (No. 69 horizon of Prof. X. Stainier). The Ghlin marine bands cannot be correlated with any of the fossiliferous horizons previously recorded by Messrs. F. L. Cornet and A. Briart, as they occur among strata which neither crop out at the surface nor had ever yet been reached in underground workings. The author assumes further that his readers will not for a moment confound these marine bands with the stratigraphically much higher *Carbonicola*-bands recorded by the late Mr. A. de Vaux at the same colliery of Nord-du-Flénu, at the respective depths of 1,518

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Kessel, the bore-hole first entered the Carboniferous Limestone, then penetrated the Devonian rocks, and was stopped on the verge of, if not actually within, the Cambro-Silurian. At Lanaeken, too, after a few feet of the very lowest Coal-measures had been passed through, the Carboniferous Limestone was struck. Now, these industrially barren results at all events solve the problem of the southern boundary of the new coal-field: the subterranean trend of the Carboniferous Limestone is approximately indicated by a straight line drawn from Kessel to Lanaeken. Further, it seems probable that the axis of the Campine basin is deflected southward between those two points so as to coincide with the general trend of the main folds of the Namur basin, and the southern boundary of the Coal-measures probably follows to some extent the same trend. Moreover, the palæontological and palæobotanical evidence confirms the mineralogical and lithological evidence, which in its turn agrees with the deductions drawn from the general stratigraphy, the whole furnishing a remarkable instance of concordance between the results achieved by several investigators working independently along different lines of research.

The resemblances between the Carboniferous Limestone of Kessel and that of Yorkshire appear to the authors to furnish an additional confirmation of the hypothesis previously put forward of a correlation between the two coal-fields.

In the third chapter and its appendix, occupying 253 pages, a detailed account is given of the sections proved by 65 bore-holes in Belgium, 88 bore-holes in Dutch Limburg, and 69 bore-holes in the neighbouring German territory. In the last-named sixty-nine, although the Coal-measures were struck in nearly every case, only twice are coal-seams mentioned; but lignite was found in the newer strata overlying the Coal-measures in 24 instances. On the other hand, coal-seams in the Coal-measures were struck in 56 of the Dutch, and in 55 of the Belgian, borings.

The fourth chapter deals with the subterranean orography of the Palæozoic and the Red [Permo-Triassic?] Rocks. Speaking generally, this buried surface in the Campine constitutes a peneplain dipping very gently north-north-eastward or northward; while in Dutch Limburg and the neighbouring German territory it is extraordinarily rugged, presenting deeply-cut, steep-sided valleys, separated one from the other by precipitous ridges. On careful investigation, these prove to have a general south-easterly and north-westerly trend, and are really due to a series of parallel faults; not, as might be at first thought, to the agencies of erosion.

A general description of the Coal-measures, as they occur in the area under review, supplemented by synoptical tables, forms the fifth chapter. A barren zone (*Hb* in the sections) is traceable from the west of the Campine into Dutch Limburg, and makes a fairly good horizon for purposes of classification, despite its variable thickness (282 to 623 feet). Below these barren measures, coal-seams are of infrequent occurrence, occasionally interbedded with shales, and the percentage of volatile matter in the coal never exceeds 26. The deeper down the bore-hole is pushed below the barren measures the farther apart are the seams met with, and their volatile matter diminishes *pari passu*; the average thickness of the 68 workable seams struck in Belgium is 2¼ feet, while that of the 85 struck in Dutch Limburg is 3¼ feet. Whence it may be inferred that the seams increase in thickness from west to east. These Lower Coal-measures in the Campine attain a known thickness of 14,317 feet, 154 feet of which are workable coal; in Dutch Limburg, out of a proved thickness of 13,809 feet of equivalent strata, 279 feet are workable coal. The

direct superposition of the lowermost Coal-measures on Upper Devonian rocks, in one or two localities, recalls similar occurrences in Shropshire and Staffordshire, where the Carboniferous Limestone is wanting and Coal-measures are seen to rest immediately upon Cambro-Silurian or upon Devonian formations.

The Coal-measures above the barren zone are industrially by far the most important in the Campine, and have been the most actively explored. The percentage of volatile matter in the coal ranges from a minimum of 20·2 to a maximum of 47·1. Generally speaking, this percentage diminishes, though slowly, as the depth increases. In the middle and upper portions of the series, the seams are very numerous and mostly interbedded with shales. It is noticeable also that, amid a group of coal-seams exhibiting the normal downward diminution of volatile matter, a seam will suddenly make its appearance with a percentage of volatile matter far higher than those of neighbouring seams: this implies the occurrence of cannel-coals. In a proved thickness (in the Campine) of 23,544 feet of such measures, no less than 262 seams exceeding 16 inches in individual thickness were passed through, without counting innumerable thinner seams, the total thickness of workable coal amounting to 765 feet. In Dutch Limburg, the uppermost portion of this division of the Coal-measures does not appear to have been explored as yet, and in a proved thickness of 6,221 feet of strata 73 workable seams were struck, yielding a total of 179 feet of workable coal. The percentage of volatile matter ranges from 17·2 at Wolfshagen to 40 at Huis-Doenrade. Ten important faults are named in the synoptical tables, and from the maps and sections the Campine Coal-measures are seen to form two shallow synclines separated by a rather flattened anticline. In Dutch Limburg, the existence of a more southerly syncline even than that of the Southern Campine is to be inferred; the central of the three synclines is the one that has been most thoroughly explored, but a certain northward sweep of the strata revealed by the Gheel borings prefigures the discovery of a fourth and northernmost syncline in the direction of Antwerp. Wherever the Coal-measures have been struck in the region described the dip has proved to be slight; it increases southward, from the neighbourhood of the outcrop of the barren zone onward, and increases still more [redacted]

The eighth chapter deals with the faults and the water-bearing horizons, and in the ninth the conclusions at which the authors have arrived are summarized. L. L. B.

MANGANIFEROUS IRON-ORES OF LIENNE, BELGIUM.

Les Gisements ferro-manganésifères de la Lienne. By Joseph Libert. *Annales de la Société géologique de Belgique,* **1905**, *vol. xxxii., Bulletin, pages* **144-154** *and* **3** *plates.*

About the end of the year 1886 or the beginning of 1887 active working was begun on the manganiferous deposits of the Lienne valley, a rather out-of-the-way district, then recently opened up by means of new roads and railway-lines. Three mining concessions had been granted by the Belgian Government: of these, one, the Meuville concession, covering an area of 403 acres, has never been the object of mining operations of any great importance. The Moët-Fontaine concession (covering 378 acres) was worked for some ten years, and the Bierleux-Werbomont concession (3,422 acres) was worked for nearly seventeen years. Operations have now been suspended, for economic reasons. The rocks of the district are chiefly of Cambrian age, in the Upper Salmian division of which the manganiferous ores occur among hæmatitic phyllites. West of the river, however, Lower Devonian rocks make their appearance, mantling over the Cambrian, and in one instance the ore-deposit appears to be faulted against them.

Now, a glance at the map shows that much of the Bierleux-Werbomont concession lies outside the area of Upper Salmian, the only metalliferous rock-group in the district. Indeed the mineral wealth of the region appears to be localized within a pretty restricted basin barely 2 miles long, and cut into two nearly equal halves by the Lienne river. The principal and lowest ore-bed reaches in the central portion of the field a depth of 1,300 feet or more below the valley-floor. East of the Lienne it has been worked down to a depth of 200 feet from the surface, without any trace of folding having been observed. From the available data it would be possible to estimate for this bed alone the quantity of ore as reaching several millions of tons, but when it comes to a question of actually-workable ore this estimate is subjected to a considerable discount. Be that as it may, the deposit is still of enough importance to justify a future resumption of mining operations, when the conditions of the ore-market prove more favourable and the needs of the metallurgist more insistent.

The average assays of the ore show a percentage of 38 for iron and manganese combined; the percentage of manganese alone varies from 16 to 18 and that of iron alone from 19 to 22: the manganese diminishing as the iron increases, and *vice versa*. The percentage of silica and alumina averages 30·6, and may be considered very high; there is also rather more than 3 per cent. of lime, in association with sulphur and phosphorus. In truth, the ore is a mixture of oxides and double carbonates and silicates of iron and manganese: the oxides occurring chiefly in the superficial portions of the ore-body which have suffered most alteration from atmospheric agencies, and giving a blackish tinge to the mass. Deeper down is a dark-brown ore, containing a smaller proportion of oxides. The double carbonate of iron and manganese occurs in a subcrystalline form in pinkish-white venules seaming the mass of ore, and may be properly defined, either as a manganiferous siderite or as a ferriferous diallogite. Fairly-thick venules of white quartz are also of frequent occurrence.

There is no question that the ore-body is a bedded deposit, and the roof

is very clearly marked off from the floor, the former consisting of a fine-grained thinly-foliated violet phyllite, and the latter of an alternation of coarse-grained irregularly-foliated quartz-phyllites with thin bands of manganese-ore. The principal and lowest ore-bed has an average workable thickness of 2¼ feet, calculated from variations ranging from a minimum of 8 inches to a maximum of 5 feet. The lie is very irregular, the bed often pinching-out or being disturbed by faults. Moreover, the ore is of so extreme a toughness as to make its working both difficult and costly.

Some considerable distance above the principal bed occurs another one, which has been chiefly explored to the rise, on the right bank of the river, by means of a drift some 600 feet long. A little working has been done on it, and the ore proves to be of extremely variable composition. On the whole, it would probably not repay working.

Other outcrops of ore have been recorded, and are mapped by the author; but too little exploration-work has been done on them to admit of anything being said in regard to the composition of the ore.

L. L. B.

COAL-BASINS OF CARMAUX-ALBI, FRANCE.

Note sur le Bassin Houiller de Carmaux-Albi. By JULES LAROMIGUIÈRE. *Bulletin de la Société d'Histoire Naturelle de Toulouse*, 1905, *pages* 172-177 *and* 1 *map*.

Since the author first gave an account of these coal-basins in 1890, a great deal of fresh evidence has been furnished by the thirteen borings which have been put down within the past fifteen years, and by new deep-level workings. In the Sainte-Marie pit, Carmaux, four additional coal-seams (designated by the letters G, H, I and J) have been struck below seam E; and, although occasionally separated by great thicknesses of grits, conglomerates and shales, they constitute a notable addition to the richer portion of the Coal-measures. The united thickness of all the coal-seams (A—J) now proved in the Carmaux basin exceeds 100 feet.

In the Albi basin, deep-level exploration-work has confirmed the evidence obtained from the Camp-Grand bore-hole, and the four known coal-seams attain a united thickness of some 60 to 80 feet. This is without reckoning the seam of meagre coal (10 to 13 feet thick) which occurs 100 feet below the undermost

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COAL-FIELD OF FRENCH LORRAINE.

(1) *Sur l'Allure du Bassin Houiller de Sarrebrück et de son Prolongement en Lorraine française.* By JULES BERGERON *and* PAUL WEISS. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, **1906**, *vol. cxlii., pages* **1398-1400.**

The authors consider the facts which they place on record to be of considerable practical importance, since the hope is thereby fostered of finding, south of the known Coal-measure area, that part of the basin whence was derived the overthrust mass which corresponds to the Saarbrücken basin.

The Saare coal-belt extends, with a north-easterly and south-westerly strike from Nordfeld on the north to Martincourt (in the department of Meurthe-et-Moselle) on the south, and possibly beyond that. Only in the northern portion do the Coal-measures crop out at the surface, between Benbach and the Saare valley. They are conformably overlain on the north by the Lower and Middle Permians, which abut directly against the southern flank of the Hunsrück, made up of Devonian rocks. South-westward, the Coal-measures disappear beneath the Mesozoic deposits, and are only revealed by some scattered workings and more especially by bore-holes, whereof the westernmost are those of French Lorraine. On the south, the coal-belt is suddenly cut off along an imaginary line passing through Neunkirchen and Saarbrücken, an interruption generally attributed to a fault which presumably brings down the Bunter grits against the Coal-measures. The foregoing data lead to the conclusion that the Saare coal-field does not possess the character of a basin or syncline to which we are accustomed in so many coal-fields, and a recent exposure in the Frankenholz concession shows that the Saarbrücken Coal-measures rest upon an anticline of Autunian grits. This abnormal condition of things is repeated at other localities; thus, at Petite Rosselle and Merlesbach newer Coal-measures have been struck beneath older Coal-measures. Then while, in the Abaucourt boring, Stephanian or Upper Westphalian strata have been struck at great depths, the Atton and Éply borings (north of the first-named) have traversed Lower and Middle Westphalian measures, the oldest horizons being nearest the Abaucourt boring: here again there seems to be proof that the newer are underlying the older strata.

All this leads to the inference that the entire Saarbrücken basin is in reality a great overthrust mass, whereof the southern rim corresponds with the crest of a buried anticline. The sheet or mantle of Coal-measures has survived on the northern flank of the anticline, but has been eroded away from its southern flank. Certain facts are adduced in favour of this hypothesis, and the age of the overthrust is shown to be pre-Triassic. It is further shown that the overthrust mass could have only come from the south-east. Lower Carboniferous strata are known to occur on the western flank of the Vosges, and this implies the existence of a depression in that area at the dawn of the Carboniferous period. Probably, that depression existed throughout Carboniferous time, and Coal-measure sediments were deposited in it. We know that the depression (supposedly filled up with Coal-measures) continued during the Permian, the Triassic, and a part of the Jurassic age, since the respective strata occur in that area.

(2) *Sur la Flore et sur les Niveaux relatifs des Sondages Houillers de Meurthe-et-Moselle.* By R. ZEILLER. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, **1907**, *vol. cxliv., pages* **1137-1143.**

In this paper, the author gives an account of his examination of no less than 10,000 plant-impressions, obtained by splitting up the cores from the

bore-holes which have been put down of late years along the presumed prolongation of the Saarbrücken coal-field. These bore-holes, nine in number, have all struck Coal-measures, have penetrated them for considerable depths, but in no case have reached older rocks. It may be remembered that five coal-seams have been proved at Pont-à-Mousson, nine at Éply, not one at Lesménils (in 2,470 feet of Coal-measures), or at Bois-Greney (in 640 feet of Coal-measures), only five seams exceeding 20 inches in thickness at Atton, four at Dombasle, one only at Jezainville and at Martincourt respectively, and four at Abaucourt.

From these many thousand specimens of plant-impressions, the author was enabled to determine 145 species of plants, some of them hitherto unknown. He gives a full list of those which are of especial interest, either from the point of view of the palæobotanist, or from that of the practical geologist eager to correlate the various horizons. A certain number of species in this list were supposed until now to be exclusively characteristic of the Saarbrücken Coal-measures; but the main importance of the author's investigation resides perhaps in the conclusions which it enables him to draw, as to the respective horizons of the measures. He shows that the beds passed through at Abaucourt undoubtedly belong to the Ottweiler group of the Stephanian; those traversed in the eight other bore-holes are assigned to various horizons of the Saarbrücken-schichten (group) of the Westphalian.

There is cumulative evidence that, as one passes from the bore-hole of Pont-à-Mousson to that of Atton, and thence to that of Éply, continuously-lower beds are met with: the uppermost beds of the second bore-hole partly corresponding with the lowermost of the first-named, and the lowermost beds of the second corresponding in part with the uppermost beds of the third bore-hole. Messrs. R. Nicklès and H. Joly had already surmised that the Coal-measures of Éply were slightly older than those of Atton and Pont-à-Mousson; which latter on the other hand would be older than those of Lesménils, and these in turn older than the Coal-measures of Dombasle. The palæobotanical evidence brought forward by Prof. Zeiller entirely confirms this supposition.

(3) *Sur les Dômes du Terrain Houiller en Lorraine française.* By J. BERGERON.

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UNSUCCESSFUL BORINGS FOR COAL IN PICARDY, FRANCE.

Résultats de deux Sondages profonds en Picardie. By J. GOSSELET. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxliii., pages* 201-203.

South-west of Abbeville, the Saigneville bore-hole has just been stopped at a depth of 1,397 feet from the surface. After passing through 60 feet of recent and Quaternary deposits, 197 feet of Chalk, 285 feet of Gault and Lower Cretaceous, and 443 feet of Jurassic, it entered the Devonian grits. For comparison, the details of the Péronne bore-hole are given as follows:— Recent and Quaternary deposits, 33 feet; Chalk, 656 feet; Gault and Lower Cretaceous, 177 feet; Jurassic, 721 feet; Devonian, 52½ feet (stopped). Besides the remarkable absence of Triassic strata, there is a noticeable thinning-out of the Lias. Indeed, the Jurassic is not only incomplete in its lower members, but also in its upper, and fossils that can be determined with any certainty are scarce.

These bore-holes confirm the well-known views of the author in regard to the subterranean or deep-lying geology of Artois and Picardy. He has perseveringly maintained that below the Chalk-plain the older systems of the Dinant basin extend in the form of anticlines of Devonian grits and shales and synclines of Carboniferous Limestone. Occasionally, a patch of the Coal-measures is found in the centre of these synclines. On this hypothesis the bore-holes were put down, for it seemed just possible that in the Somme valley (which admittedly corresponds to a geological syncline) the underlying Jurassic and Palæozoic strata might reproduce the synclinal arrangement of the overlying Chalk. Here, if anywhere in Picardy, there was a chance of lighting upon a good mass of Coal-measures; possibly also on the saliferous Trias, connecting up the Triassic deposits of Lorraine with those of England; and possibly again on the pisolitic iron-ores characteristic of the Bray district.

These hopes have been disappointed, and the bore-holes prove that, if the Coal-measure basin of Lorraine does really extend far to the westward, its prolongation must lie to the south of the Bray district. L. L. B.

SHEAR-PLANES IN THE ST. ÉTIENNE COAL-FIELD, FRANCE.

Sur l'Existence de Phénomènes de Charriage antérieurs au Stéphanien dans la Région de Saint-Etienne. By P. TERMIER *and* G. FRIEDEL. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 1003-1005.

Below the Coal-measures of St. Étienne is a curious formation which has been erroneously described as a sedimentary deposit granitized in places before the deposition of the Coal-measures; but the authors' investigations now show it to be a plane of shear or crush, wherein a great variety of rocks, among which granite predominates, have been mylonized almost beyond recognition. This testifies to enormous shearing movements, etc., previous to the Stephanian age. The shear-plane is especially observable in the western portion of the coal-field on its southern and western margins, forming between the Coal-measures and the mica-schists *in situ* an almost continuous belt, extending for well nigh 17 miles from St. Étienne to Cizeron. Apart from local thickenings, it does not generally exceed 100 to 130 feet in thickness, and has much the aspect of a sedimentary group underlying the Coal-measures with a near approach to conformity. But the mica-schists upon which it rests are absolutely unconformable to the Coal-measures, and especially on the southern border their average strike makes an angle of 45 degrees with that of the

Coal-measure syncline. There is, conseqently, much the same unconformity, but a tectonic one, between the mica-schists and the shear-belt: the former show signs of crushing and dragging-out in the neighbourhood of the latter. As to the basal conglomerates and red shales of the Coal-measures which overlie the shear-belt, the junction being very clearly marked, it may be noted that pebbles of all the rocks that occur in the shear-belt are found in the conglomerates, in exactly the same mylonized condition as that in which they are in that belt. Hence it may be inferred that these Coal-measures were laid down in a basin, large areas of the floor of which were covered by the relics of a shear-belt, which itself was unconformably overlying the mica-schists. Owing to erosion before and during the deposition of the Coal-measures, parts of this belt were completely swept away, thus allowing the Coal-measures to rest directly in places upon the mica-schists. Generally speaking, the basal portion of the belt, especially toughened and compacted by crush, has alone resisted erosion, and consists chiefly of mylonized granite. But, in certain depressions of the ancient pre-Stephanian surface, considerable masses of a granite survive which in nowise resembles the granites of the Central-Plateau type that are usually seen to traverse the gneisses and mica-schists of the district. It is a porphyritic alkaline granite, analogous to those of Mont Blanc and the Pelvoux. South of the coal-field, in the mountainous region where the three departments of the Loire, the Haute Loire and the Ardèche meet, the highest summits consist of a similar alkaline granite, crushed and laminated, evidently sheared off by thrust-phenomena from its original site, and dragged into its present position. Where lay the original site of the rocks that now form the shear-belt, and of these granites particularly, is a problem of which the authors have not yet found the solution. L. L. B.

IRON-ORE DERIVED FROM GLAUCONITE, ARDENNES, FRANCE.

Genèse d'un Minerai de Fer par Décomposition de la Glauconie. By L. CAYEUX. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1906, *vol. cxlii., pages* 895-897.

In the department of the Ardennes, in the district of Vouziers, and more [redacted]

appearance of glauconite-grains. Hence, it is permissible to conclude that, in this ore-deposit, the very nucleus of the ferruginous particles is of glauconitic nature, masked by the secondary limonite derived from its decomposition. The Grandpré iron-ore is unique in France in respect of its derivation. Its structure and its genesis differentiate it definitely from the pisolitic ores with which it has been hitherto confused. L. L. B.

MAGNETIC IRON-ORE OF DIÉLETTE, LOWER NORMANDY.

Structure et Origine probable du Minerai de Fer magnétique de Diélette (Manche). By L. CAYEUX. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, **1906**, *vol. cxlii., pages* **716-718.**

This ore occurs along the western margin of the Flamanville granitic massif, at the north-western extremity of the Cotentin peninsula, in the form of six vertical beds, intercalated among sedimentary strata which have been metamorphosed by the granite. Three of these ore-beds are seen to crop out on the beach at low tide: the others have only been proved by underground workings extending out to sea. The age of the deposit has been the subject of some controversy, but there appears to be no longer any doubt that it dates from the Lower Devonian.

As the result of a micrographic study of specimens of the ore, the author feels justified in drawing attention to the following salient facts:—(1) The undoubted existence of ferruginous bodies within the ore which have retained all the characters of the most typical oolites, with the sole exception of the concentric structure—this having been destroyed by the development of octahedral crystals of magnetite. Originally this oolitic structure must have pervaded the entire mass of the ore. (2) The irrefutable evidence that the magnetite now occupies the place of constituents which were primarily calcareous. (3) Consequently, that the ore is derived from an oolitic limestone. It may be observed that Prof. A. Bigot has discovered fossils of the nature of corals in the immediate neighbourhood of the ferruginous beds, and Dr. Cayeux identified certain nuclei of the oolitic grains under the microscope as crinoid-débris. Two hypotheses as to the actual genesis of the ore are admissible. The first presupposes that the limestone was directly metamorphosed into magnetite and hæmatite at the time of the effusion of the granite. The second relegates the replacement of the limestone by iron-ore to a period long anterior to the effusion of the granite. Pisolitic carbonates or oxides of iron, on this hypothesis, already made up the ore-beds at the time when the metamorphic influence of the granite became effective; and therefore metamorphic action was confined to a change in the state or combination of the iron in the ore-deposit. For reasons assigned, the author favours the second hypothesis. L. L. B.

AURIFEROUS STIBNITE OF MARTIGNÉ, BRITANNY.

Das Antimonitvorkommen von Martigné in der Bretagne. By O. STUTZER. *Zeitschrift für praktische Geologie*, **1907**, *vol. xv., pages* **219-221**, *with* **4** *figures in the text.*

The gold-bearing antimony-ores of Martigné-Ferchaud, in the Breton department of Ille-et-Vilaine, have found but little prominence in geological and mining literature so far. A few years ago, Baron W. von Fircks studied the surroundings and general conditions of the Semnon mine, near Martigné, and presented to the Freiberg Academy a large collection of rock-and-ore-specimens obtained by him, accompanying each specimen with a detailed

description of the occurrence and composition of the ores. The country-rocks are predominantly black slates and yellowish-brown, fine-grained, porous quartzites, through which courses a greenstone-dyke, some 33 feet in width. This dyke pitches about 75 degrees north-north-eastward, striking from west-north-west to east-south-east, and, thanks to erosion, stands out like a reef or wall at the surface. It can be traced over a distance exceeding ⅔ mile, and is, in fact, the ore-carrier. A petrographical description is given of the greenstone, as seen under the microscope, and this appears generally to confirm the author's surmise that the rock is a highly-decomposed diorite or diabase.

Besides the stibnite (containing 0·0009 per cent. of gold), the Martigné ores include arsenical pyrites (with 0·0008 per cent. of gold), ordinary pyrites, limonite, and (more seldom) a little native gold. As the limonite and the native gold are evidently the products of atmospheric decomposition, the primary ores are restricted to the stibnite, arsenical pyrites and ordinary pyrites. The gangue consists chiefly of quartz and calcite, with which some brown spar is associated; vughs or druses are of frequent occurrence. The black slate at the salband is highly altered and much impregnated with ore, especially arsenical pyrites. Sericite is found both in the salband and in the gangue. It should be noted that the ores do not occur as continuous lodes within the greenstone, as is usually the case with stibnitic quartz-veins, but form a series of broken and lenticular fragmentary lodes, recalling rather the "ladder" or step-lodes of Beresovsk. These minor lodes occasionally intersect and are not seldom faulted, and their dip is predominantly at low angles: in thickness they range from 6½ feet down to a fraction of an inch. They rarely pass from the greenstone into the slates, and, when they do so, very soon nip out.

The lodes are probably the infilling of contraction-fissures in the greenstone, and from the point of view of their genesis they may be classified with the similar ore-occurrences of the central plateau of France. The industrial importance of the Martigné stibnites is much discounted, to say the least, by the considerable proportion of impurities present in the shape of arsenic.

L. L. B.

[redacted]

The author is expecting to secure interesting results from two pyritiferous bands which are known to occur in the Bunter Grit and the Vosges Grit of Meurthe-et-Moselle. L. L. B.

METALLIFEROUS DEPOSITS OF THE VAL DE VILLÉ, ALSACE.

Les Gîtes métallifères du Val de Villé (Alsace). By — UNGEMACH. *Bulletin de la Société française de Minéralogie,* 1906, *vol. xxix., pages* 194-282, *with* 12 *figures in the text and* 1 *map.*

Commencing with a bibliography of the subject (16 entries), the author points out that the Val de Villé, in the Alsatian Vosges, is, like the neighbouring Val de Sainte Marie, a very ancient centre of the mineral-industry. Old waste-heaps, abandoned adits and pits rediscovered in the course of the exploration-work of recent years, bear witness to its pristine activity. The fact that the ancient writers, and local traditions also, are dumb in regard to the Val de Villé, while they are so loquacious concerning the mineral wealth of Sainte Marie, is explained when one remembers that very little precious metal has been got from the former valley, while the rich finds of native silver in the latter have caused its name to re-echo "through the halls of time."

The upper portion of the Val de Villé, which is alone in question, consists of gneisses and Palæozoic shales, a belt of altered granite, some 500 to 800 feet wide, intervening between the two, and ranging from east to west. Three groups of metalliferous lodes are described: (1) the predominantly plumbiferous and cupriferous lodes of Urbeis, which crop out within or around the granitic belt; (2) the less numerous lodes of Charbes, which crop out among the shales on the southern flanks of the heights dividing the valley of that name from the Steige valley; and (3) the Triembach lodes, which occur several miles to the east of Villé in the tract of Permian or Rothliegende rocks.

Beginning with the Urbeis lodes, which yield copper, silver, lead, and more rarely zinc-ores, the author proceeds in his description from east to west, premising that all of the lodes pitch very steeply and some are absolutely perpendicular. The only mine at present worked is that of Sylvester, started in 1894: there are three veins of considerable thickness, which yield, in addition to the metalliferous ores, a vast number of magnificently-crystallized minerals, such as quartz, dolomite, calcite, fluorine, siderite, etc. Among the ores, tetrahedrite predominates, there is a little chalcopyrite, while galena, blende, marcasite, bournonite, native arsenic, etc., are of rare occurrence. The workings are conducted from four different levels joined by several shafts, and the main lode has been followed westward as far as the red Permian grit, which it does not appear to penetrate. The Donner silver-and-lead mine was worked at intervals from 1894 to 1899, the ores got from the main lode being galena, chalcopyrite, and an extremely small quantity of tetrahedrite.

The Charbes lodes have all yielded antimony-ores, occasionally zinc-ores, but never copper or lead. The Honilgoutte mine worked a series of contorted lodes of variable thickness, operations having been resumed there in 1894 to cease again somewhere about 1902. In 1900 as many as 148 workpeople were employed on that mine.

An attempt has recently been made to start once more the working of the two Triembach lodes, which crop out among the red grits by the road to Sauloch. The gangue, consisting of an altered granite, is frequently cemented by tetrahedrite, in addition to which ore and chalcopyrite, such secondary minerals as azurite (in great quantity), malachite, pyrolusite and limonite, etc., occur.

Eighty pages are devoted by the author to a detailed mineralogical and

crystallographic description of all the ores and gangue-minerals obtained from the Val de Villé, but he casts doubt on the formerly reported presence there of native gold, native silver and cobaltine. The Sylvester tetrahedrite occurs in two varieties: one rich in arsenic (6·75 per cent.) and poor in silver, and the other conversely poor in arsenic and rich in silver (5·94 per cent.); the former appears to be more distinctly an outcrop-mineral, since in depth its place is taken by the latter. The presence of as much as 1·63 per cent. of bismuth is another remarkable characteristic of the arsenical variety. The argentiferous tetrahedrite occurs in no less than seventy-one different crystalline forms, the notation of which is tabulated by the author. L. L. B.

ASPHALTIC LIMESTONES OF THE GARD, FRANCE.

Les Calcaires asphaltiques du Gard. By P. Nicou. *Annales des Mines,* **1906**, *series* 10, *Mémoires, vol. x., pages* 513-568, *with* 16 *figures in the text and* 3 *plates.*

The bituminous limestones of the Tertiary lacustrine basin in the department of the Gard, hitherto regarded as of no very great industrial consequence, promise, owing to recent discoveries, to rank among the most important of the kind known anywhere. They are distributed along a belt some 22 miles in length and 1¼ miles in breadth, striking approximately north 25 degrees east, and may be divided into two groups—on the south, the older and smaller workings of Servas, Cauvas, Le Puech and Les Fumades; on the north, separated by a gap of 5 miles from the southern group, the mining concession of St. Jean de Maruéjols and the vicinity. Between the two, several borings have been and are being put down, which have struck asphalt. In the Upper Infratongrian (Lower Oligocene) division, to which these bituminous limestones belong, there also occurs the lignite-series of Barjac, Avéjan and Célas, the lignites in which are worked on a small scale.

The existence of asphalt has long been known in the region, but the first Government concessions for mining it were not granted until 1844: these applied to the southern group, where the Servas workings alone remain in full activity. The concession of St. Jean de Maruéjols, granted in 1859, [redacted]

of bitumen, the middle one is poor and generally unworkable; but it is otherwise with the uppermost or brown seam and the lowest or black seam. The seams crop out in a hillside about 650 feet above sea-level, dip west-north-westward with a gradually diminishing steepness (from 30 degrees to *nil*), and are disturbed by strike-faults and cross-faults. A peculiar striped appearance, due to the repetition of thin streaks of bitumen interbanded with the limestone, is occasionally characteristic. The annual output of asphalt from the Servas concession averaged 600 tons between 1844 and 1890, reached a maximum of 4,600 tons from 1891 to 1895, and has decreased to 3,300 tons since 1896. In 1904 and 1905, a marked diminution of output was conditioned by momentary suspensions of mining operations, due apparently to various causes.

Turning then to the northern group of deposits, the author states that the concession of St. Jean de Maruéjols covers an area of some 702 acres; it was worked at first by inclined drifts, but for some years past all the mineral has been brought up through a shaft which it was found necessary to sink. The only seam worked has a thickness (including a central parting of unmerchantable stuff) of about 7 feet; but it is not quite clear whether this is the sole workable horizon, and fresh exploration-work, the results of which are not yet available, was started in 1906. Mining operations have been complicated by local faults and fissures, and in part arrested by water-feeders. In January, 1904, a portion of the older workings (eastern district) caved in, but as this fortunately happened on a Sunday, no one sustained injury to life or limb. The total output, from the time when operations were started there until the end of 1905, is estimated at 130,000 tons. For many years, and especially in the decade 1881-1890, the greater part of the asphalt was exported to British India; but it is now mostly taken up for London and Berlin.

A description is given of nineteen borings in the neighbourhood of St. Jean, directed to the discovery of further workable seams of bitumen; seventeen of these were put down in the years 1903 to 1905, and in five or six cases the results may be regarded as highly promising. Discussing these in detail, the author arrives at the conclusion that, in every case, the bituminous horizon which has been struck may be correlated with that already worked at St. Jean, and that its maximum thickness may approximate to 100 feet. The possible extension of the asphaltic limestone-area is limited on the east by the older rocks, and the progressive north-westerly increase in distance from the surface (or in vertical depth) of the asphaltic formation is conditioned by the dip of the beds and westward by a series of faults striking generally north 15 degrees east. Impoverishment is discernible on the north towards Fontcouverte, while southward the formation seems to disappear. How far it extends to the west is as yet unknown.

Three further bore-holes, put down in 1904-1905 between the northern and the southern groups of asphalt-workings, failed to strike any workable deposits.

Various theories of the origin of the bitumen, such as contemporaneous sedimentation, later sublimation from fumaroles, or from natural distillation of neighbouring coal-seams (Alais basin), etc., are passed in review; but the author does not commit himself definitely to any one of them.

In an appendix, he gives a short account of the bituminous oil-shales of Vagnas, in the department of the Ardèche, which occur at the same geological horizon (Cenomanian) as the lignites worked farther south at Connaux and Pont Saint-Esprit in the Gard. These oil-shales strike north-and-south, and dip 25 degrees westward. They were worked from 1859 to 1869, when mining

operations were suspended. The annual output averaged 6,000 tons of oil-shale (producing 12 per cent. of crude oil) and 1,800 tons of lignite, utilized as fuel at the shale-distillery on the spot. The overwhelming competition of American and Russian petroleum, and the expenditure which would be inevitably incurred in putting the workings into fit condition again, have checked any serious attempt to resume operations at Vagnas. L. L. B.

PHOSPHATIC DEPOSITS OF FRANCE.

Die Phosphatlagerstätten Frankreichs. By O. Tietze. *Zeitschrift für praktische Geologie*, 1907, *vol. xv., pages* 117-124, *with* 2 *maps in the text.*

At one time or another some forty of the French departments have borne a more or less conspicuous share in the phosphate-output of the country; but, at the present day, phosphate-workings on any considerable scale are confined to the departments of the Aisne, Ardennes, Meuse, Oise, Pas de Calais and Somme. Elsewhere the output has either dwindled to insignificance, or has ceased altogether.

Preceding his descriptions of the principal deposits with a bibliographical list consisting of eleven entries, the author groups together those departments where the phosphates occur at approximately the same geological horizon. In the group which includes the Aisne, Nord, Oise, Pas de Calais and Somme, all the deposits that are still worked belong to the Upper Cretaceous (either Senonian or Upper Turonian, as the case may be); the Gault phosphates of Boulogne and the Cenomanian phosphates of Fauquembergues have been worked out. The pockets in which the rich phosphatic sands (containing 80 per cent. or even more of phosphate of lime) are found occasionally extend to a depth of 65 feet and more; but such pockets are nowadays seldom discovered and worked, and the phosphatic Chalk itself has assumed greater industrial importance. It is not thought that this Chalk is of deep-sea origin, but that the material was laid down in small subsiding basins, varying in longest diameter from 300 to 10,000 feet, the connexion between which (and even communication with the open sea) was frequently interrupted. A careful lithological description is given of the deposits, and a comparison with the similar deposits of Bergen, in Belgium, leads to the conclusion that

[redacted]

In the Yonne, a seam was at one time worked, directly overlying the *Gryphaea*-limestone at the junction between the Lower and the Middle Lias; now the phosphate is got from an underlying gravel of flints and extremely-coarse sand immediately beneath the Brienne marls, the phosphatic band averaging 8 inches in thickness. In the neighbouring department of the Côte d'Or, the *Belemnites*-limestones of the Middle Lias decompose on weathering into an iron-raddled loam, in which the phosphatic nodules are embedded; the best workable phosphates, however, in that department occur in a seam barely 6 inches thick, which belongs to the upper horizons of the Lower Lias, yielding from 120 to 160 tons of saleable mineral per acre.

In the Haute-Saône, pale phosphatic nodules (containing from 27 to 32 per cent. of phosphoric acid) were got from a band 2 to 8 inches thick, in the clays of the topmost Lower Lias; while in the department of the Cher, phosphatic nodules were worked both in the Lower Lias and in the much younger Gault. In the *causses* (limestone-plateaux) of the southern group of departments, which includes the Aveyron, Lot, Tarn and Tarn-et-Garonne, the phosphates form the infilling of dyke-like fissures extending 300 feet or more down in the Lower Oolitic limestones. The phosphate is evidently of much later age than the limestone, is generally white or grey, but occasionally iron-raddled, and contains on an average 50 per cent. of tricalcic phosphate (some times as much as 80 per cent.). Its association in the Aveyron with basalts and tuffs points to its eruptive origin—probably in the form of a precipitate from thermal springs. A statistical table of the output from the French phosphate-workings, covering the years 1886 to 1904 inclusive, accompanies the paper.

L. L. B.

AIX-LA-CHAPELLE COAL-FIELD, GERMANY.

Die Gliederung der Aachener Steinkohlenablagerung auf Grund ihres petrographischen und palæontologischen Verhaltens. By H. WESTERMANN. *Verhandlungen des naturhistorischen Vereins der preussischen Rheinlande,* 1905, *vol. lxii., pages* 1-64 *and* 1 *plate.*

The records of the coal-mining industry in this area, extending as they do over a period of nine centuries, mark it out as the oldest worked colliery-district on the continent of Europe. Ancient, however, though it may be, the industry has developed so slowly that it has only attained real economic importance within the last few decades. Employing at present about 9,000 workpeople, the Aix-la-Chapelle or Aachen colliery-district yields an output of roughly 2,000,000 tons in the year. In view of the facts just recited, it is perhaps rather curious that so few geologists have concerned themselves with this coal-field, so far as published work goes, and no attempt had hitherto been made to fix the horizon of the productive Coal-measures or to investigate their possible correlation with those of neighbouring areas, more especially the Rhenish-Westphalian basin.

The surface of the Aachen coal-field, considered as a whole, slopes north-eastward, and hydrographically it forms part of the Meuse basin, the most important east-bank tributary of that river, the Roer, sweeping round the district in a vast curve, the concavity of which is directed westward. The basement-rocks are the Cambrian formations of the Venn plateau, upon which rests unconformably the great belt of Devonian strata, which make up the terraced north-western scarp of the plateau. The Devonian rocks are immediately succeeded by the Carboniferous Limestone and the Coal-measures, the latest Palæozoic formation in the district. On the west, the Coal-measures are overlain by the Senonian (Upper Cretaceous) deposits, while north-

ward and eastward they are covered by Middle Tertiary beds mantled over by widespread sheets of drift. These covering strata attain a thickness of some 2,000 feet or more, and are conspicuously water-bearing: the Coal-measures of the Wurm basin, however, are shut off from them by a clayey band known as the *Baggert*, which is probably the outcome of the former weathering of the anciently exposed Carboniferous surface.

The coal-field is made up of two distinct basins, one of which dips from south-west to north-east over a breadth of about 7½ miles; connecting up with this and dipping in the same direction along the line Moresnet-Aachen-Neusen, the second basin appears to pass north-westward into a third basin, that of Dutch Limburg. The two first-mentioned basins are separated by an Upper Devonian anticline, the northern limb of which exhibits a reversed, that is, a south-easterly dip of the strata. On the north-western flank of this ridge, the Carboniferous Limestone is wanting, and so the productive Coal-measures there follow hard upon the Devonian. It is inferred that a gigantic overthrust of the Devonian has taken place over the Carboniferous, and is in some way connected with the great Eifel fault which is traceable through Belgium and French Flanders into the Pas de Calais. While the north-western or Wurm basin is filled with productive Coal-measures throughout its entire extent, the Eschweiler or Inde basin (which really breaks up westward into several distinct basins) is in the valley alone of the Inde deep enough to include within itself the Upper Carboniferous. The precise extent of these basins has not yet been determined; but recent bore-holes point, at any rate, to an undoubted connexion between the Wurm coal-basin and that of Dutch Limburg. This basin has been compressed by the northward travelling Aachen overthrust, into a series of sharply-folded minor anticlines and synclines, the plication diminishing, however, in intensity towards the Dutch frontier. The Inde basin forms a single regular syncline open to the eastward, but its southern limb is overfolded. Strike-faults and cross-faults are both very numerous, but the downthrows (with some notable exceptions) are inconsiderable. The strike-faults probably date from before the deposition of the Rhenish Bunter Sandstone, while the cross-faults are of Tertiary age. Singly, the coal-seams exceed seldom 3½ feet in thickness; but, in the Eschweiler basin their combined thickness approaches 46 feet of [redacted]

some importance, are confined to the Eschweiler basin, where they occur at six different horizons, and the so-called main conglomerate (1,300 feet below the Traube seam) exceeds 160 feet in thickness. The coals of the Inde basin surpass all other Prussian coals in their calorific capacity; those of the western portion of the Wurm basin are anthracitic in character.

With regard to fossils, animal-remains are of small importance in this coal-field as compared with the plant-remains. The latter mostly occur in the immediate roof of the coal-seams, and, to make his collection of fossil plants, the author searched every seam that is worked. Of these plants, he furnishes an elaborate catalogue, garnished with a running commentary.

Analogies between the Aix-la-Chapelle Coal-measures and those of Westphalia are emphasized, and reasons are adduced for considering the coal-seams of the Wurm basin as of later date than those of the Eschweiler basin. Impressions of ferns, comparatively rare in the Eschweiler seams, are extremely abundant in those of the Wurm basin. The anthracitic character of the coal in the western portion of the latter basin is possibly explicable as owing to the metamorphic influence of the mighty overthrust which came from the southward. Where the measures are less sharply folded, the seams are correspondingly more bituminous. The entire thickness of the coal-bearing Carboniferous rocks of the Aix-la-Chapelle coal-field is said to exceed 6,500 feet. Many bore-holes have been put down within recent years, establishing the connexion with the Westphalian coal-field, and the only gap at present unfilled measures some 14 miles in extent. The basins of Mons, Liége and Valenciennes seem to link up with the Aix-la-Chapelle coal-field on the west.

The paper is accompanied by a bibliography of the subject and a correlation-table (wherein it is shown that the productive Coal-measures of Aix-la-Chapelle extend from below the Millstone Grit into strata which are the equivalents of the so-called "transition" Coal-measures of England). Throughout the paper the author lays very great stress on the palæobotanical evidence, and he supplies a range-diagram of the fossil plants. He concludes that deeper-lying seams than those yet known will be ultimately struck in the Eschweiler basin, and so, too, in the Wurm basin. The exhaustion of the coal-resources of the Aix-la-Chapelle district is not likely to occur for many centuries to come.

L. L. B.

RECENT BORE-HOLES AND SINKINGS IN THE RHENISH-WESTPHALIAN COAL-FIELD.

Ueber neue Aufschlüsse im Rheinisch-Westphälischen Steinkohlenbecken. By P. KRUSCH. *Zeitschrift der Deutschen geologischen Gesellschaft*, 1906, *vol. lviii., Protokolle, pages* 25-32.

It had long been known that the eastern boundary of the productive measures in the Rhenish-Westphalian coal-field coincides more or less with the meridian of Soest, with, of course, certain re-entrants and salients corresponding to the successive anticlines and synclines. Of late years, a series of bore-holes have been put down east and south-east of Lippborg, the results of which tend to show that the boundary of the productive Coal-measures runs approximately through Hultrop, leaving Lippborg on the west and Haus Assen on the east. Farther east and east-south-east, however, the Kessel, Krewinkel and Brockhausen bore-holes show a local eastward extension of the productive measures. This, in the author's opinion, indicates the existence of a separate basin, while at Hultrop and Haus Assen an ancient anticline, consisting of barren Carboniferous, Kulm and Devonian strata, juts out eastward into the productive measures. The Krewinkel basin is one of the

synclines of the Witten main basin, and most probably the southernmost of them.

The above-mentioned bore-holes have also indicated the possibility of coal being found beyond the boundary of the productive measures. In some cases, fragments of coal-seams destroyed by the waves of the Cretaceous sea have been washed down into the fissures which then were open in the *Stringocephalus*-limestone (Middle Devonian). In other cases, in consequence of the folding of the strata and the southward thrust of the Carboniferous surface, patches of Coal-measures have been preserved among the synclines of the older rocks. But these explanations fail to account adequately for the numerous finds of abnormally rich gas-coal east-south-east of Unna. Further bore-holes will doubtless furnish an explanation of the apparent anomaly.

In the course of a few remarks on the cross-faults which characterize the tectonics of the coal-field, the author draws attention to the extreme variations in the amount of downthrow along the strike of these faults. Thus, the Courl fault, beginning at the locality after which it is named, has there a downthrow of barely 33 feet, while 2½ miles farther to the north-west the downthrow exceeds 1,970 feet; and it diminishes again as rapidly as it increases. In this respect, a cross-fault may be compared with a cross-tear in a piece of cloth that is stretched and bears a moderate load: a curvilinear depression of that portion of the cloth is observed which is most heavily loaded (most subject to the influence of gravity).

The northward depression of the syncline of productive measures brings continuously-younger seams within reach, the farther north one goes in the coal-field; and the younger the seams are hereabouts the more bituminous they are, generally speaking. But the expectation that only the coals richest in gas, and plenty of them, would be found in the northern portion of the Rhenish-Westphalian basin has been falsified. This is mostly due to the intervention of main anticlines between the synclines and of local synclines within the same; and an exception of this kind is illustrated by recent sinkings at the Auguste-Viktoria colliery, north of Recklingshausen, where at horizons which usually yield gas-coals, the meagre coals (upper division) were struck, vaulted up into an anticline.

A series of bore-holes, put down on the left bank of the river Rhine, west [redacted]

II.—REPORT OF THE CORRESPONDING SOCIETIES' COMMITTEE AND OF THE CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, YORK MEETING, 1906.*

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Much consideration has been given by the Committee to the subject of railway-fares, in order to ascertain whether any steps could be taken to secure reduced rates under certain circumstances for members of the Corresponding Societies. Considering, however, the number of railway-companies which would have to be approached and the diversity of local arrangements, it has been felt to be impossible for the British Association to deal with the subject as a whole. Societies which desire concessions should therefore apply directly to the railway-companies of their respective districts for such privileges; and with the view of strengthening such applications the Council of the British Association, on the recommendation of the Corresponding Societies Committee, have authorized the issue of a form of warrant to all Corresponding Societies which send representatives to the Annual Conference of Delegates, certifying that the Societies in question are recommended by the Council as suitable applicants for any privileged tickets that the railway-companies may grant. These warrants may be obtained at the present Conference, or at the offices of the British Association.

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The following Corresponding Societies nominated delegates to represent them at the Conferences:—The Institution of Mining Engineers, Mr. J. A. Longden; and the Manchester Geological and Mining Society, Mr. Wm. Watts.

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First Meeting, August 2nd, 1906.

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The Report of the Corresponding Societies Committee was read by the Secretary. It was resolved to apply for a grant of £25.

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Second Meeting, August 7th, 1906.

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Mr. W. Whitaker, Section C (Geology), solicited the aid of local societies in the work of the Geological Photographs Committee, and expressed the hope that certain societies would assist the Committee for investigating the Speeton beds at Knapton.

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* *Report of the Seventy-sixth Meeting of the British Association for the Advancement of Science, York, August, 1906*, 1907, page 45.

It was resolved to recommend that the Secretary of the Conference (Mr. F. W. Rudler) be nominated to serve as delegate on the Megalithic Monuments Registration Committee.

A letter was read from Mr. E. Heawood, Recorder of Section E (Geography), calling the attention of local societies to the work of the committee which was appointed last year for investigating "The Quantity and Composition of Rainfall, and of Lake- and River-discharge." Local observations on the latter subject would be useful, if made systematically, so as to admit of co-ordination with work already done.

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RESEARCH-COMMITTEES APPOINTED BY THE GENERAL COMMITTEE AT THE YORK MEETING: AUGUST, 1906.*

1.—RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.	Grants. £ s. d.
Seismological observations	*Chairman.*—Prof. J. W. Judd. *Secretary.*—Dr. J. Milne. Lord Kelvin, Dr. T. G. Bonney, Mr. C. V. Boys, Sir George Darwin, Mr. Horace Darwin, Major L. Darwin, Prof. J. A. Ewing, Mr. M. H. Gray, Dr. R. T. Glazebrook, Prof. C. G. Knott, Prof. R. Meldola, Mr. R. D. Oldham, Prof. J. Perry, Mr. W. E. Plummer, Prof. J. H. Poynting, Mr. Clement Reid, Mr. Nelson Richardson and Prof. H. H. Turner.	40 0 0
To co-operate with the Committee of the Falmouth Observatory in their magnetic observations.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Dr. R. T. Glazebrook. Prof. W. G. Adams, Captain Creak, Mr. W. L. Fox, Prof. A. Schuster, Sir A. W. Rücker and Dr. Charles Chree.	40 0 0
To investigate the erratic blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Dr. J. E. Marr. *Secretary.*—Mr. P. F. Kendall. Dr. T. G. Bonney, Mr. C. E. De Rance, [redacted]	21 16 6

[redacted]

1.—RECEIVING GRANTS OF MONEY.—*Continued.*

Subject for Investigation or Purpose.	Members of the Committee.	Grants.
		£ s. d.
The quantity and composition of rainfall, and of lake- and river-discharge.	*Chairman.*—Sir John Murray. *Secretaries.*—Prof. A. B. Macallum and Dr. A. J. Herbertson. Sir B. Baker, Prof. W. M. Davis, Prof. P. F. Frankland, Mr. A. D. Hall, Mr. N. F. Mackenzie, Mr. E. H. V. Melvile, Dr. H. R. Mill, Prof. A. Penck, Dr. A. Strahan and Mr. W. Whitaker.	10 0 0
Corresponding Societies Committee for the preparation of their report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. F. W. Rudler. Rev. J. O. Bevan, Sir Edward Brabrook, Dr. H. T. Brown, Dr. Vaughan Cornish, Dr. J. G. Garson, Principal E. H. Griffiths, Mr. T. V. Holmes, Mr. J. Hopkinson, Prof. R. Meldola, Dr. H. R. Mill, Mr. C. H. Read, Rev. T. R. R. Stebbing, Prof. W. W. Watts, and the General Officers of the Association.	20 0 0
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2.—NOT RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.
The rate of increase of underground temperature downwards in various localities of dry land and under water.	*Chairman and Secretary.*—Prof. H. L. Callendar. Lord Kelvin, Sir Archibald Geikie, Prof. Edward Hull, Prof. A. S. Herschel, Prof. G. A. Lebour, Prof. C. H. Lees, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. Edward Wethered, Dr. A. Strahan, Prof. Michie Smith and Mr. B. H. Brough.
The consideration of the teaching of elementary mechanics, and the improvement which might be effected in such teaching.	*Chairman.*—Prof. Horace Lamb. *Secretary.*—Prof. J. Perry. Mr. C. Vernon Boys, Prof. Chrystal, Prof. Ewing, Prof. G. A. Gibson, Prof. Greenhill, Principal Griffiths, Prof. Henrici, Dr. E. W. Hobson, Mr. C. S. Jackson, Sir Oliver Lodge, Prof. Love, Prof. Minchin, Prof. Schuster, Prof. A. M. Worthington and Mr. A. W. Siddons.
The collection, preservation and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretary.*—Prof. W. W. Watts. Dr. T. G. Bonney, Dr. T. Anderson, Prof. E. J. Garwood, Prof. S. H. Reynolds, Mr. A. S. Reid, Mr. W. Gray, Mr. H. B. Woodward, Mr. R. Kidston, Dr. J. J. H. Teall, Mr. H. Coates, Mr. C. V. Crook, Mr. G. Bingley, Mr. R. Welch and Mr. W. J. Harrison.
To record and determine the exact significance of local terms applied in the British Isles to topographical and geological objects.	*Chairman.*—Mr. Douglas W. Freshfield. *Secretary.*—Mr. W. G. Fearnsides. Lord Avebury, Mr. C. T. Clough, Prof. E. J. Garwood, Mr. E. Heawood, Dr. A. J. Herbertson, Col. D. A. Johnston, Mr. O. T. Jones, Dr. J. S. Keltie, Mr. G. W. Lamplugh, Mr. H. J. Mackinder, Dr. E. J. Marr, Dr. H. R. Mill, Mr. H. Yule Oldham, Dr. B. N. Peach, Prof. W. W. Watts and Mr. H. B. Woodward.
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TIES OF THE BRITISH ASSOCIATION FOR 1906–1907.—*Continued.*

Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
E. Hawkesworth, Crossgates, Leeds.	81	None	5s.	Transactions, occasionally.
Norman Treliving, 51, Lofthouse Place, Leeds.	77	None	6s.	Transactions, occasionally.
orporation Museum. W. A. Evans, 24, Fosse Road South, Leicester	350 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, half-yearly.
I. A. Clubb, M.Sc., Free Public Museum, Liverpool.	88	10s. 6d. and 2s. 6d.	£1 1s. and 10s. 6d.	Proceedings and Transactions annually.
R. C. F. Annett, 4, Buckingham Avenue, Sefton Park, Liverpool.	5[illegible]0	None	£1 1s. and 10s. 6d.	Transactions and Report, annually.
Capt. E. C. Dubois Phillips, R.N., 14, Hargreave's Buildings, Liverpool.	[illegible]40	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions and Report, annually.
Royal Institution. W. A. Whitehead, B.Sc.	70	None	£1 1s. and 10s. 6d.	Proceedings, annually.
City of London College, White Street, Moorfields, E.C. H. Norman Gray.	80	None	5s.	Journal, monthly.
A. Earland, 31, Denmark Street, Watford.	403	None	10s.	Journal, half-yearly.
Jas. Kewley, M.A., King William College, Castletown, Isle of Man.	110	2s. 6d.	7s. 6d. and 5s.	Proceedings, quarterly; Transactions, occasionally.
F. Zimmern and J. H. Reed, 16, St. Mary's Parsonage, Manchester.	600	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly.
, John Dalton Street, Manchester. Sydney A. Smith.	300	None	£2 2s., £1 5s., and £1.	*Transactions of The Institution of Mining Engineers*, monthly.
E. C. Stump, Malmesbury, Polefield, Blackley.	213	5s.	6s.	Transactions and Report, annually.
Theodore Gregory, 3, York Street, Manchester.	205	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College. E. Meyrick ..	280	1s. 6d.	3s. and 5s.	Report, annually.
G. Alfred Lewis, M.A., Albert Street, Derby.	420 Membs., Associates & Students	£1 1s. None	Members £1 11s. 6d.; Associates and Students, £1.	*Transactions of The Institution of Mining Engineers*, monthly.
L. T. O'Shea, The University, Sheffield.	306	None	£1 10s.	*Transactions of The Institution of Mining Engineers*, monthly.
W. A. Nicholson, St. Helen's Square, Norwich.	277	None	5s.	Transactions, annually.
M. Walton Brown, Neville Hall, Newcastle-upon-Tyne.	1,[illegible]50	None	£1 5s. and £2 2s.	*Transactions of The Institution of Mining Engineers*, monthly
W. Wells Bladen, Stone, Staffs.	510	5s.	5s.	Report and Transactions, annually.
H. N. Dixon, M.A., 23, East Park Parade, Northampton.	210	None	10s.	Journal, quarterly.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1906-1907.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of, 1829.	Northumb. N. H. Soc. ..	Hancock Museum, Newcastle-upon-Tyne. N. H. Martin, F.L.S., and C. E. Robson.	430	None	£1 1s.	Transactions, annually.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Prof. J. W. Carr, M.A., University College, Nottingham.	184	2s.	5s.	Report and Transactions, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3 County Place, Paisley	630	5s.	7s. 6d.	Report, annually; Meteorological Obs., occasionally.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	390	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, D.Sc., 105, Freehold Street, Rochdale.	247	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Linden House, Rochester.	186	None	5s.	*Rochester Naturalist*, quarterly.
Somersetshire Archæological and Natural History Society, 1849	Som'setsh. A.N.H. Soc.	The Castle, Taunton. Rev. F. W. Weaver, Rev. E. H. Bates and C. Tite.	661	10s. 6d.	10s. 6d.	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	G. M. Clark, South African Museum, Cape Town.	207	None	£2	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union	Rev. R. Ashington Bullen, Englemoor, Heathside Road, Woking.	45 Societies	None	Minimum 5s.	*South-Eastern Naturalist*, annually.
Southport Literary and Philosophical Society	Southport Lit. and Phil. Soc.	Arthur Quayle, 409, Lord Street, Southport.	145	None	7s. 6d.	Proceedings, annually.
South Staffordshire and Warwickshire Institute of Mining Engineers, 1867	S. Staffs. Inst. Eng. ..	Alexander Smith, M.Inst.C.E., 3, Newhall Street, Birmingham.	192	£1 1s. and 10s. 6d.	£1 11s. 6d. and £1 1s.	*Transactions of The Institution of Mining Engineers*, monthly.
Tyneside Geographical Society, 1887 ..	Tyneside Geog. Soc. ..	Geographical Institute, St. Mary's Place, Newcastle-upon-Tyne. Herbert Shaw, B.A., F.R.G.S.	1,000	None	10s.	Journal, annually.
Vale of Derwent Naturalists' Field Club, 1887.	Vale of Derwent Nat. F. C.	W. Johnson, Byer Moor, Burnopfield, Co. Durham.	102	None	2s. 6d.	Transactions, occasionally.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C. ..	Museum, Warwick. C. West, Cross Cheaping, Coventry.	75	2s. 6d.	5s.	Proceedings, annually
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C. ..	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore.	260	10s.	10s.	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Rev. Wm. Lower Carter, M.A., F.G.S., Hopton, Mirfield.	304	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	The Museum, Hull. T. Sheppard, F.G.S.	406 and 2,700 Associates	None	10s. 6d.	Transactions, annually; *The Naturalist*, monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. Dr. Tempest Anderson, and C. E. Elmhirst.	480	None	£2	Report, annually.

Catalogue of the more important Papers, and especially those referring to Local Scientific Investigations, published by the Corresponding Societies during the Year ending May 31st, 1906.*

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—. "Note on *Janassa bituminosa*, Schlot., from the Marl Slate, Thickley, Durham." *The Naturalist*, 1905, pages 220-222, 1905.

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INDEX TO VOL. XXXII.

EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

The following contractions are used:—

M. C.—The Midland Counties Institution of Engineers.
M. G.—Manchester Geological and Mining Society.
M. I.—Midland Institute of Mining, Civil and Mechanical Engineers.
N. E.—The North of England Institute of Mining and Mechanical Engineers.
N. S.—The North Staffordshire Institute of Mining and Mechanical Engineers.
S. I.—The Mining Institute of Scotland.
S. S.—The South Staffordshire and Warwickshire Institute of Mining Engineers.

A.

[redacted]

B.

C.

D.

E.

F.

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G.

H.

J.

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P

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T.

U.

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W.

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To illustrate Prof. W. Galloway's Paper on "An Appliance for Automatically Stopping and Restarting Mine-wagons."

FIG. 1.—SECTIONAL ELEVATION.

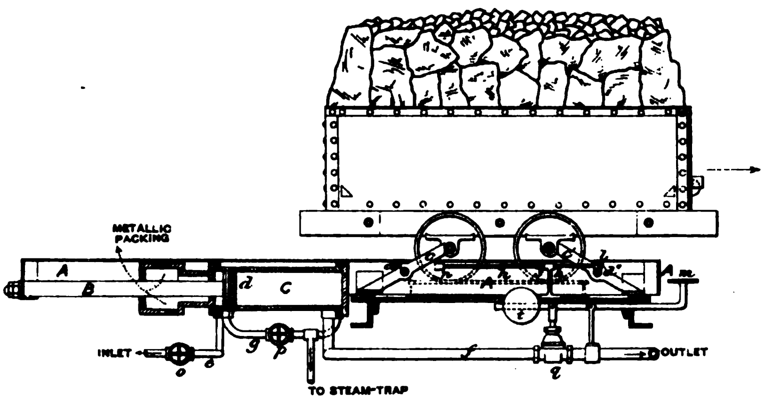


FIG. 2.—PLAN.

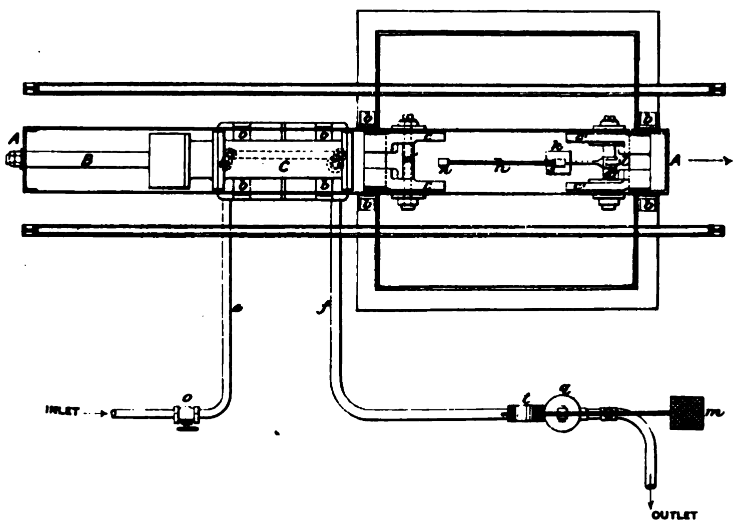
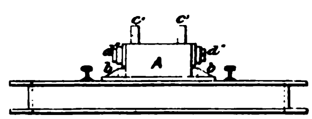


FIG. 3.—END ELEVATION.



Scale, 3 Feet to 1 Inch.

Andw Reid & Compy Ltd Newcastle upon Tyne

Fig. 5.–Giersberg Apparatus: 1900 Type.

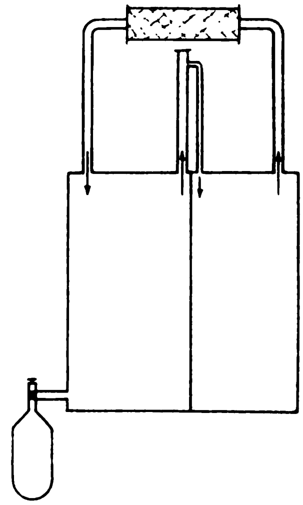
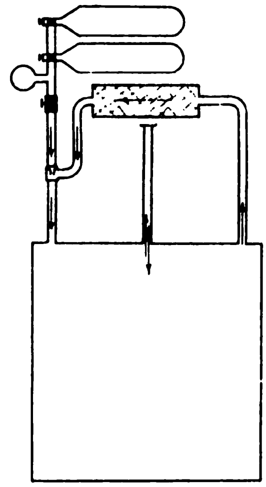
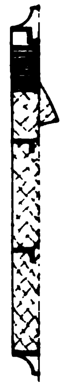


Fig. 6. –Giersberg Apparatus: 1901 Type.





Scale. 2 Feet to 1 Inch.

Fig. 7.–...atus: App...

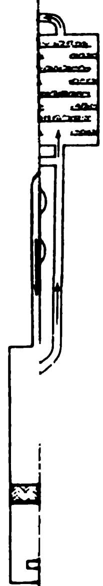


Fig 11.–Pneumatogen: I Type.

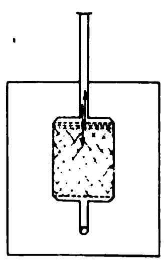
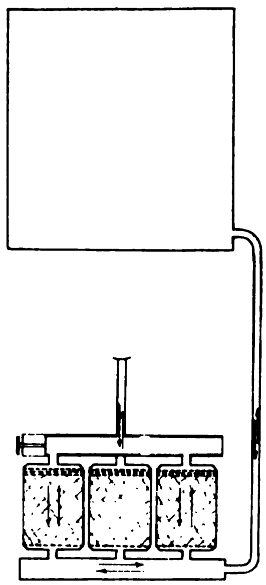


Fig. 12.–Pneumatogen: II Type.



...le. 2 Feet to 1 Inch.

"Sinking and Tubbing" etc.

FIG. 1.—GRIT-PILLARS IN HAIGH MOOR COAL-SEAM.

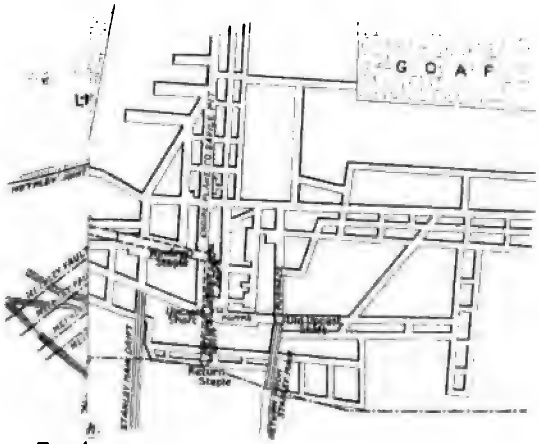
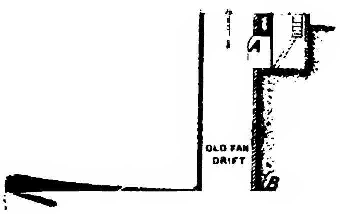


FIG.
OF TU

—SECTION SHEWING POSITION
AND DAM IN OLD UPCAST SHAFT

DEPTH FROM SURFACE. Feet. Ins.	THICKNESS OF NEW TUBBING Ins.



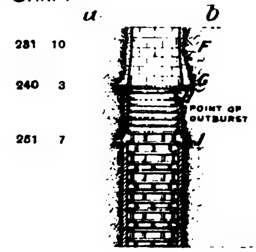
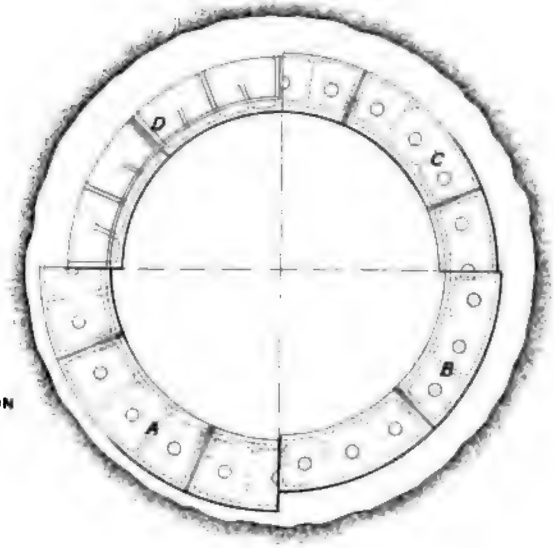


Fig. 8.—Plan of Tapered Cribs and Base Ring of Tubbing.



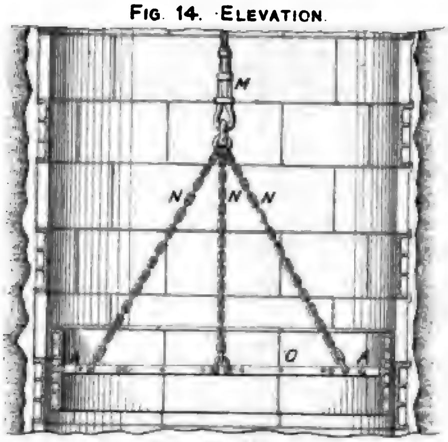
Shaft.

1 Inch.

. 11.—Section of Tubbing.

Tool used for Lowering Rings of Tubbing in Old Downcast Shaft.

Fig. 14. Elevation.



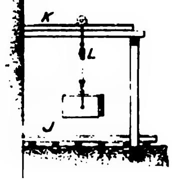
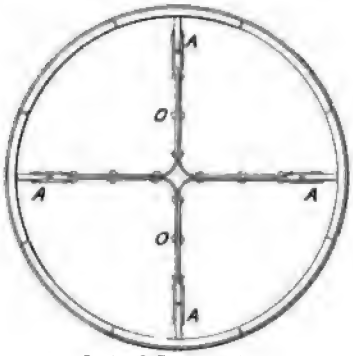
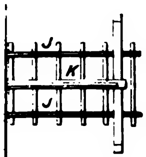


Fig. 5.—Plan.

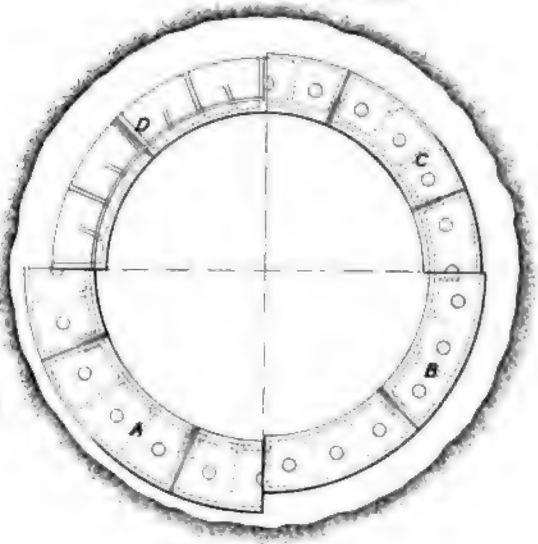




Scale. 6 Feet to 1 Inch.

"and Tubbing" etc.

Fig. 8.—Plan of Tapered Cribs and Base Ring of Tubbing.



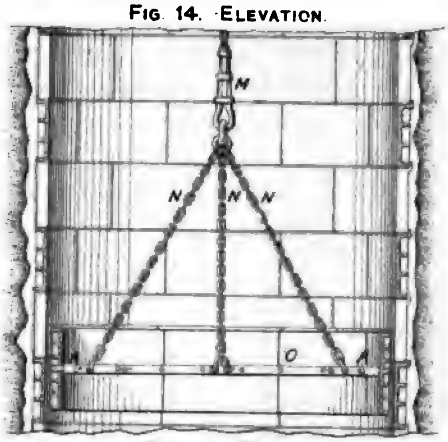
Shaft.

1 Inch.

. 11.—Section of Tubbing.

Tool used for Lowering Rings of Tubbing in Old Downcast Shaft.

Fig. 14. Elevation.



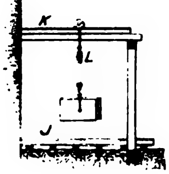
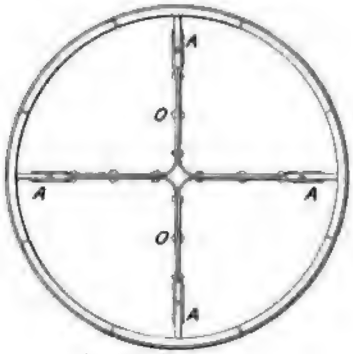
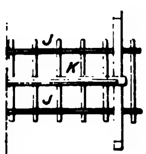


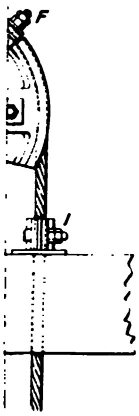
Fig. 5.—Plan.





Scale. 6 Feet to 1 Inch.

...RANGEMENT ON HEAD-GEAR.



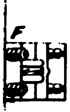
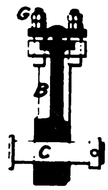


FIG. 25.- SECTION THROUGH LINE YZ OF FIG. 23.



Scale, 2 Feet to 1 Inch.

WIRE-ROPE CONDUCTOR FASTENING AT PIT-BOTTOM.

FIG 21.—SIDE ELEVATION.

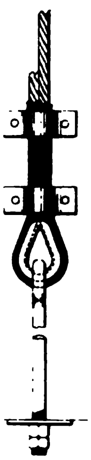
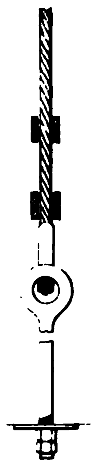


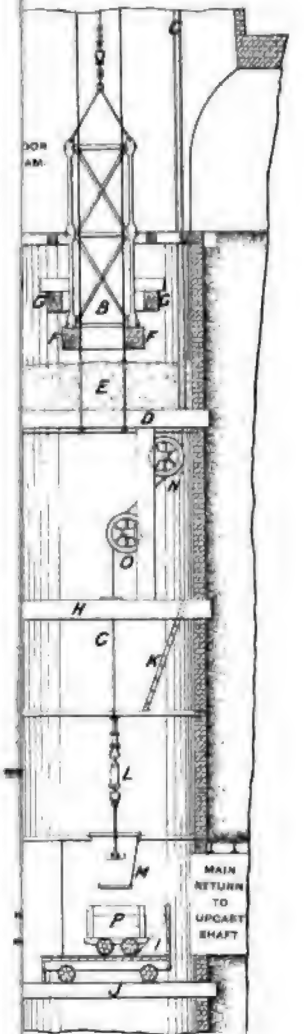
FIG. 22.—END ELEVATION.



Scale, 2 Feet to 1 Inch.

METHOD OF SINKING, WITH UNDER-LEVEL DRIFTS.

26.—SIDE ELEVATION.



Scale, 12 Feet to 1 Inch.

FIG. 27.—ELEVATION.

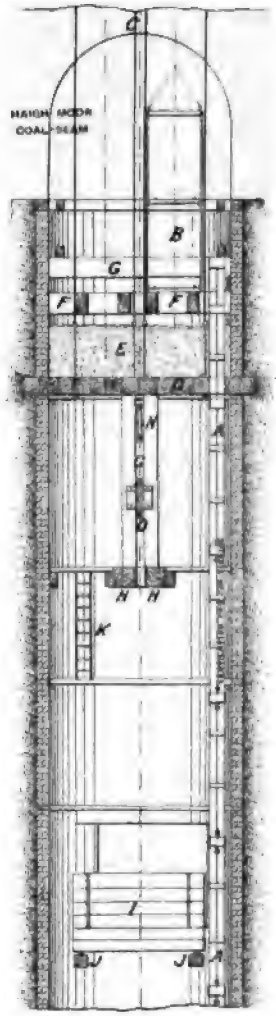
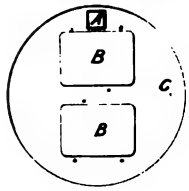
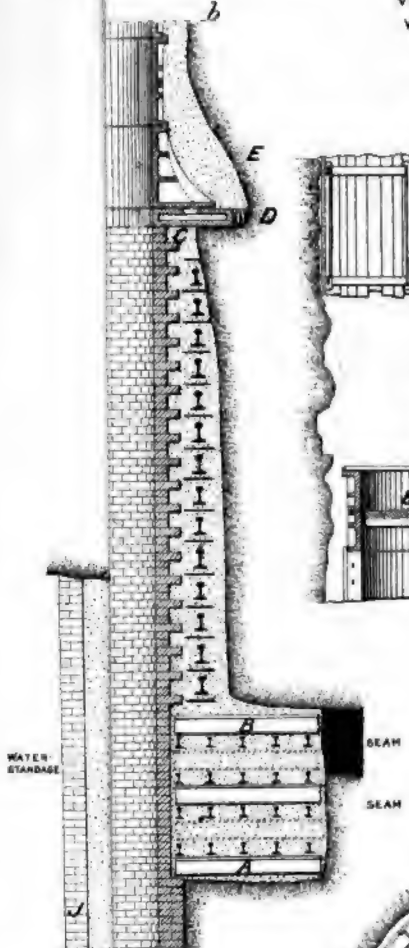


FIG. 28.—PLAN.





VENTILATION SCAFFOLD USED WHEN PUTTING IN TUBBING.

FIG. 37.—ELEVATION.

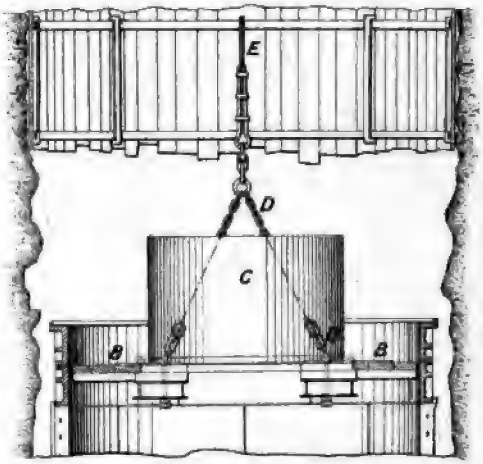
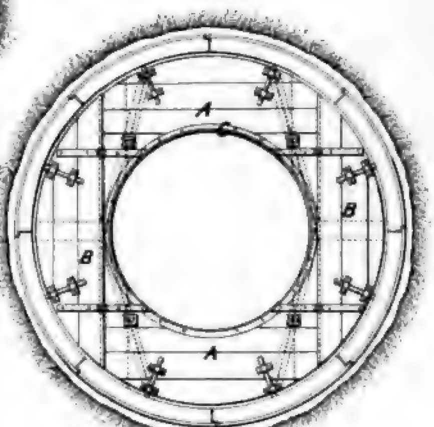
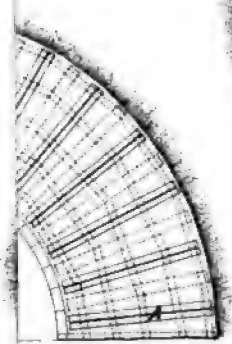


FIG 38.—PLAN.



... OR BASE.



Scale, 6 Feet to 1 Inch.

5.—Record-diagram of Steam-pressure in Accumulator.

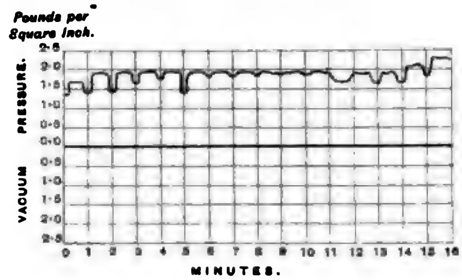


Fig. 3.—End Elevation.

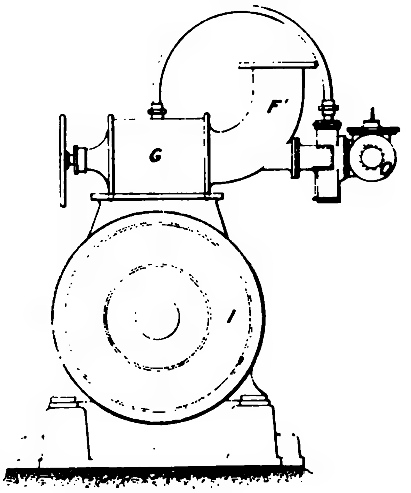
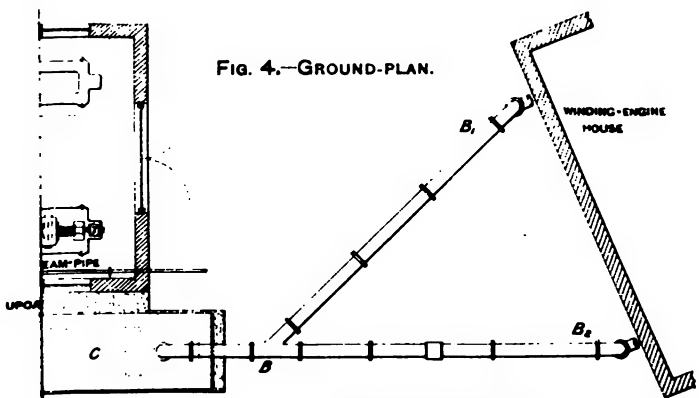
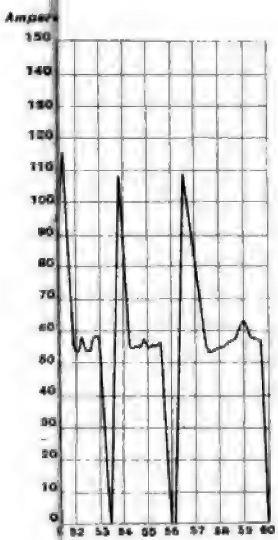
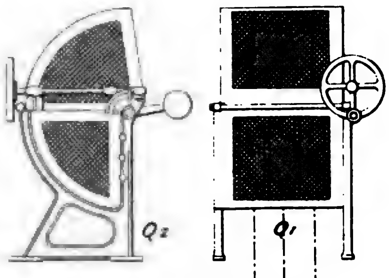


Fig. 4.—Ground-plan.

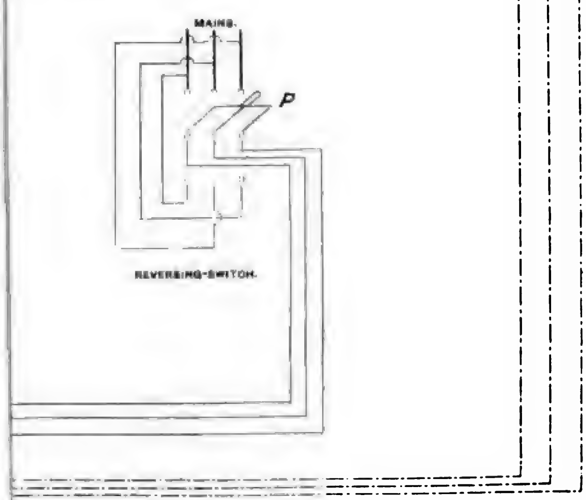


Scale, 18 Feet to 1 Inch.



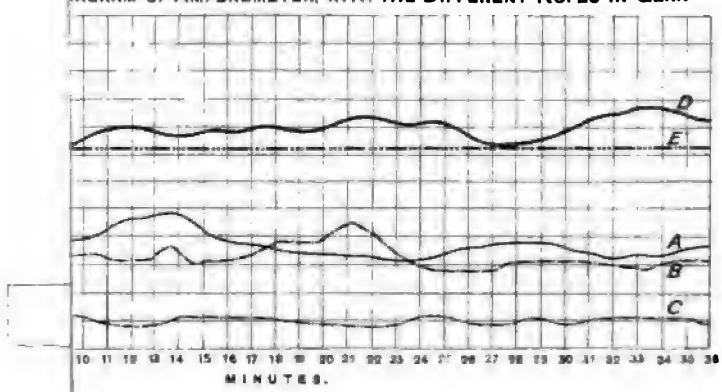


LIQUID STARTING-SWITCH.



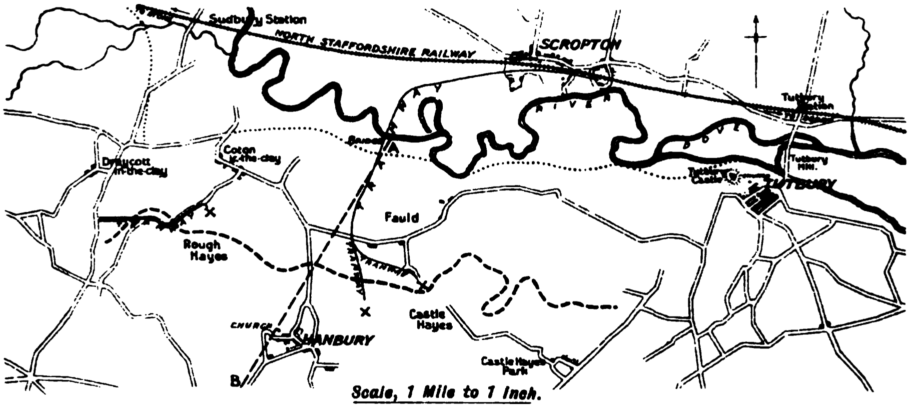
REVERSING-SWITCH.

IAGRAM OF AMPEREMETER, WITH THE DIFFERENT ROPES IN GEAR.



To illustrate Mr. T. Trafford Wynne's Paper on "Gypsum" etc.

Fig. 1.—Sketch Plan of Gypsum-deposits.

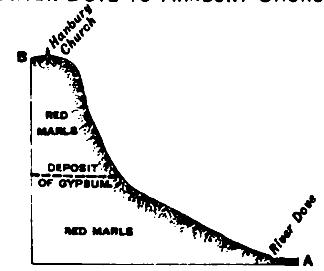


Scale, 1 Mile to 1 Inch.

REFERENCES.

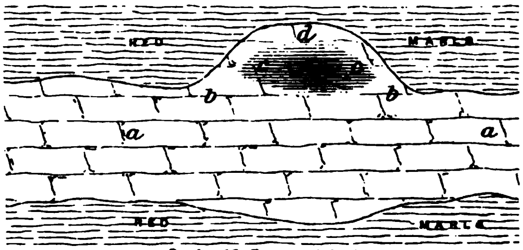
RAILWAY. ROAD.
TRAMWAY. × MINE.
OUTCROP OF GYPSUM-DEPOSIT.

Fig. 2.—Section of Surface from River Dove to Hanbury Church.



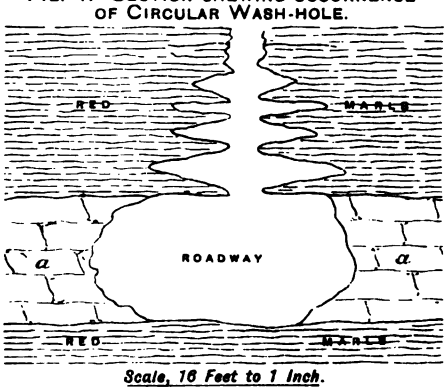
Horizontal Scale, 5,280 Feet to 1 Inch.
Vertical Scale, 300 Feet to 1 Inch.

Fig. 3.—Section shewing occurrence of Hard Stone.



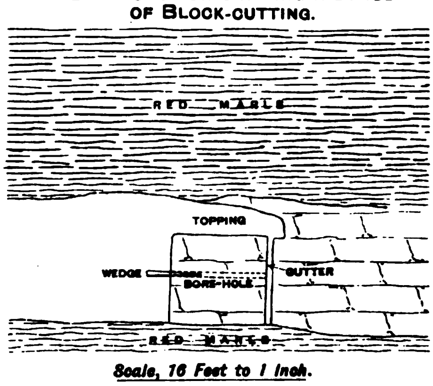
Scale, 16 Feet to 1 Inch.

Fig. 4.—Section shewing occurrence of Circular Wash-hole.



Scale, 16 Feet to 1 Inch.

Fig. 5.—Section shewing Method of Block-cutting.



Scale, 16 Feet to 1 Inch.

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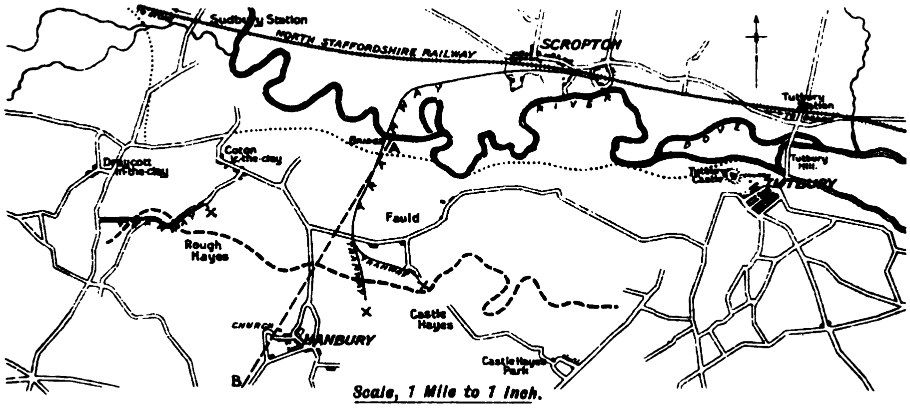
To illustrate Mr. T. Trafford Wynne's Paper on "Gypsum" etc.

Fig. 1.—Sketch Plan of Gypsum-deposits.



Scale, 1 Mile to 1 Inch.

REFERENCES.

	RAILWAY.		ROAD.
	TRAMWAY.	×	MINE.
	OUTCROP OF GYPSUM-DEPOSIT.		

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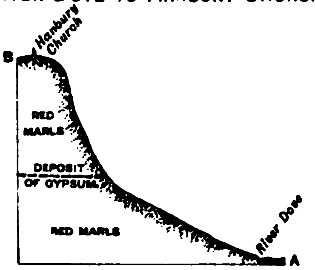

Horizontal Scale, 5,280 Feet to 1 Inch.
Vertical Scale, 300 Feet to 1 Inch.

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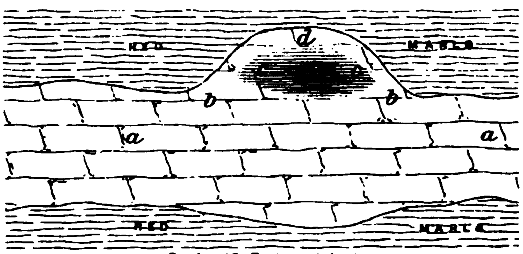
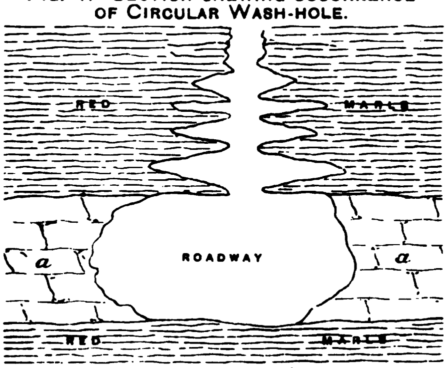


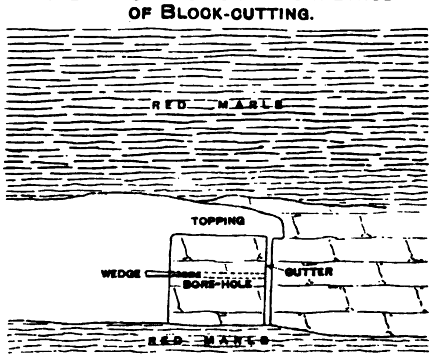
Scale, 16 Feet to 1 Inch.

Fig. 4.—Section shewing occurrence of Circular Wash-hole.



Scale, 16 Feet to 1 Inch.

Fig. 5.—Section shewing Method of Block-cutting.



Scale, 16 Feet to 1 Inch.

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To illustrate Mr. H. W. G. Halbaum's "Notes on Underground Fans as Main Ventilators."

Fig. 1.– Fan working in A Seam.

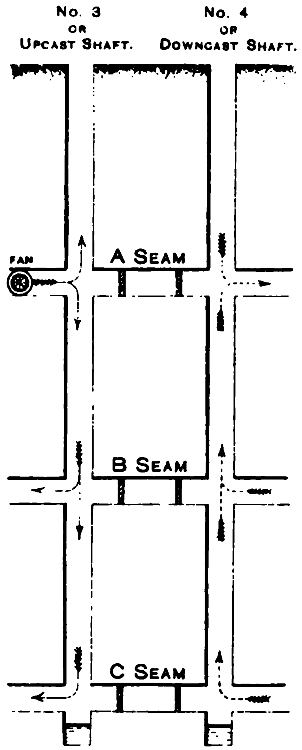


Fig 2.—Fan working in B Seam.

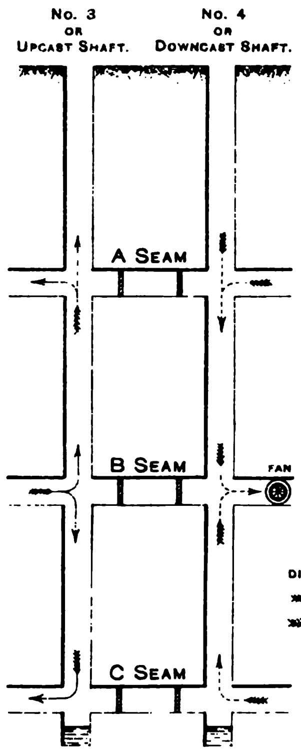
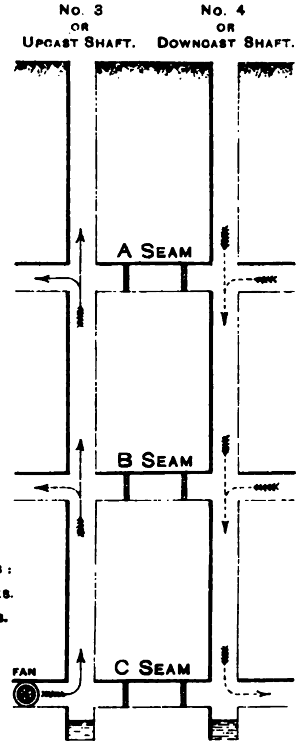


Fig. 3.- Fan working in C Seam



REFERENCES.

DIRECTION OF AIR-CURRENTS:

→ HIGHER PRESSURES.

- - → LOWER PRESSURES.

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Fig. 7.—Plan of Single Bricking-Ring.

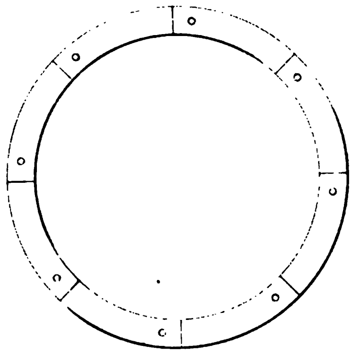


Fig. 9.—Section showing Reduction in Diameter of Shaft from 12 Feet to 9 Feet.

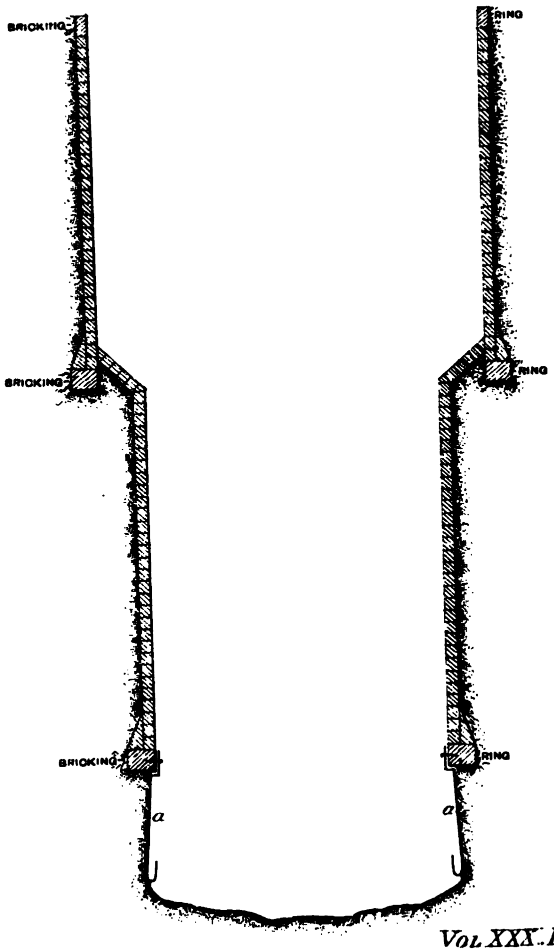


Fig. 7.—Plan of Single Bricking-Ring.

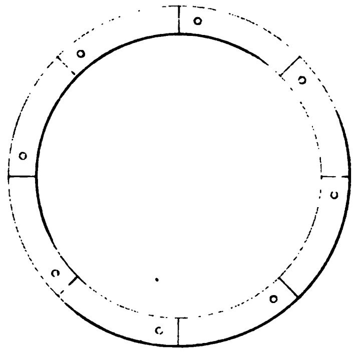
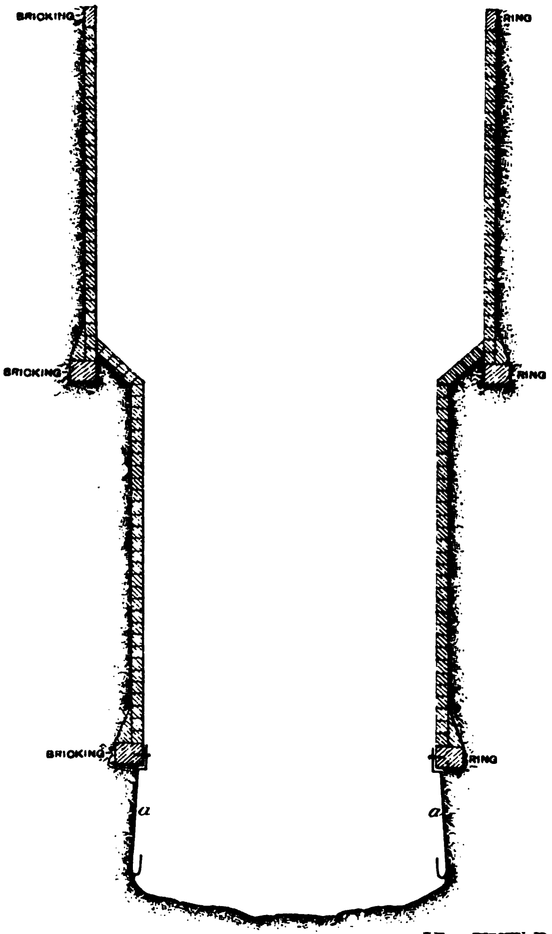


Fig. 9.—Section showing Reduction in Diameter of Shaft from 12 Feet to 9 Feet.



To illustrate Mr. G. Ness' Paper on "Effects of Acceleration" etc.

FIG. 1.

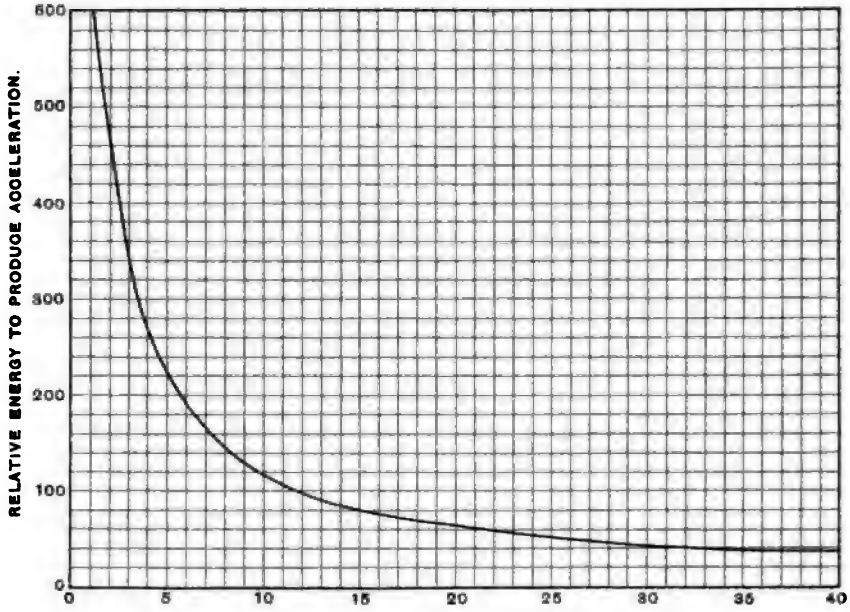


FIG. 2.

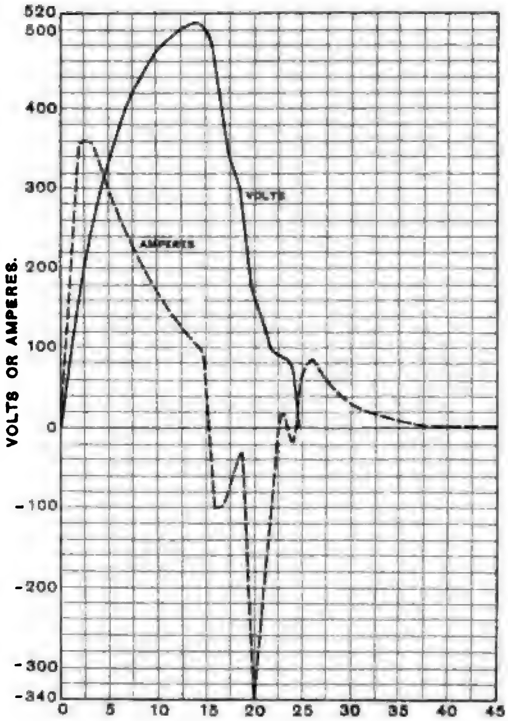
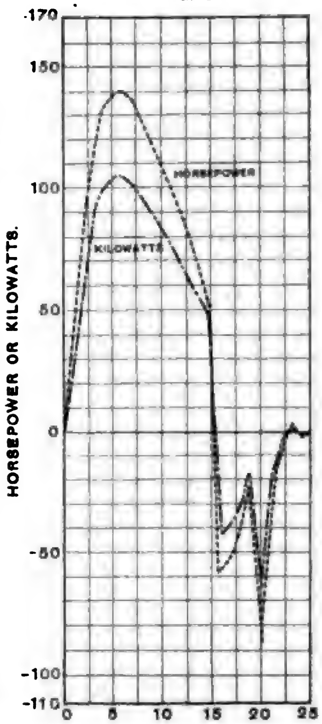
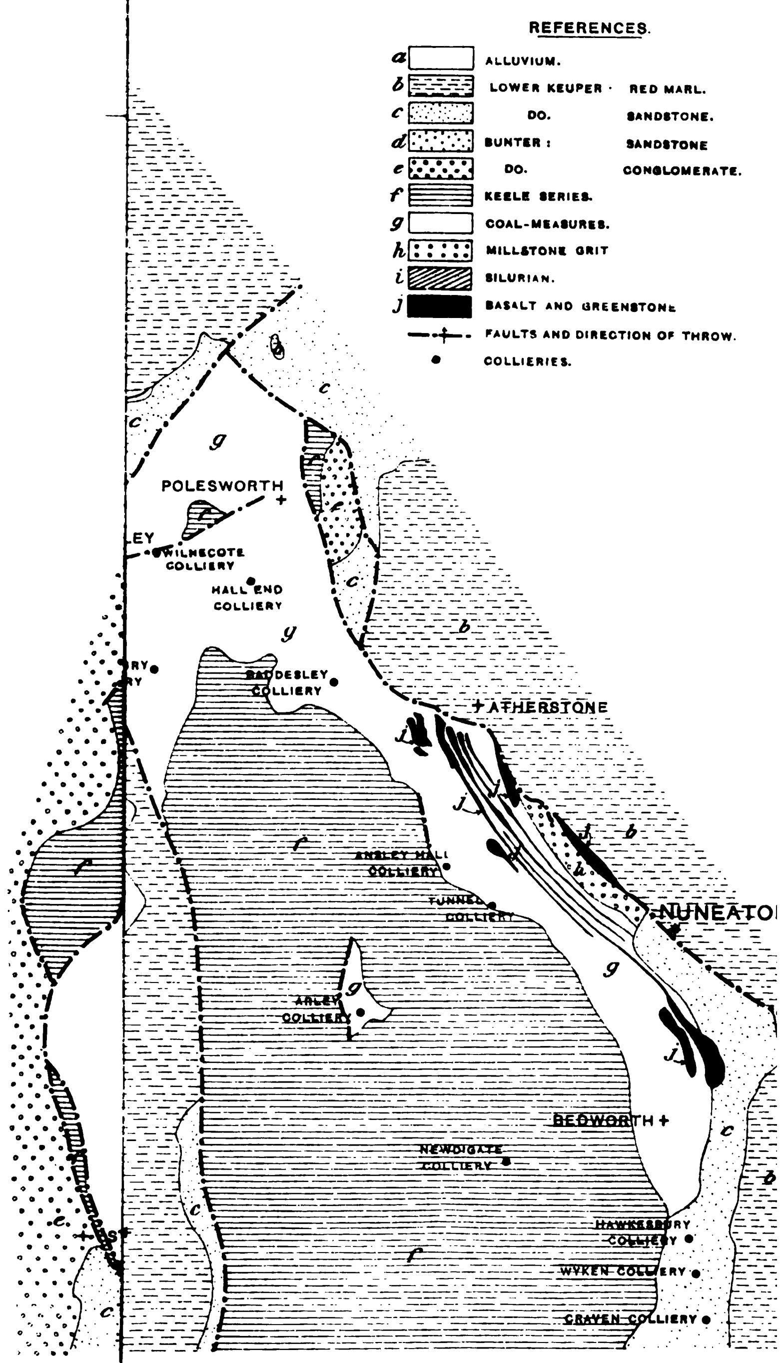


FIG. 3.




REFERENCES.
a ALLUVIUM.
b LOWER KEUPER · RED MARL.
c DO. SANDSTONE.
d BUNTER : SANDSTONE
e DO. CONGLOMERATE.
f KEELE SERIES.
g COAL-MEASURES.
h MILLSTONE GRIT
i SILURIAN.
j BASALT AND GREENSTONE
FAULTS AND DIRECTION OF THROW.
COLLIERIES.
POLESWORTH
WILNECOTE COLLIERY
HALL END COLLIERY
BADDESLEY COLLIERY
ATHERSTONE
ANSLEY HALL COLLIERY
TUNNEL COLLIERY
NUNEATO
ARLEY COLLIERY
BEDWORTH
NEWDIGATE COLLIERY
HAWKESBURY COLLIERY
WYKEN COLLIERY
CRAVEN COLLIERY

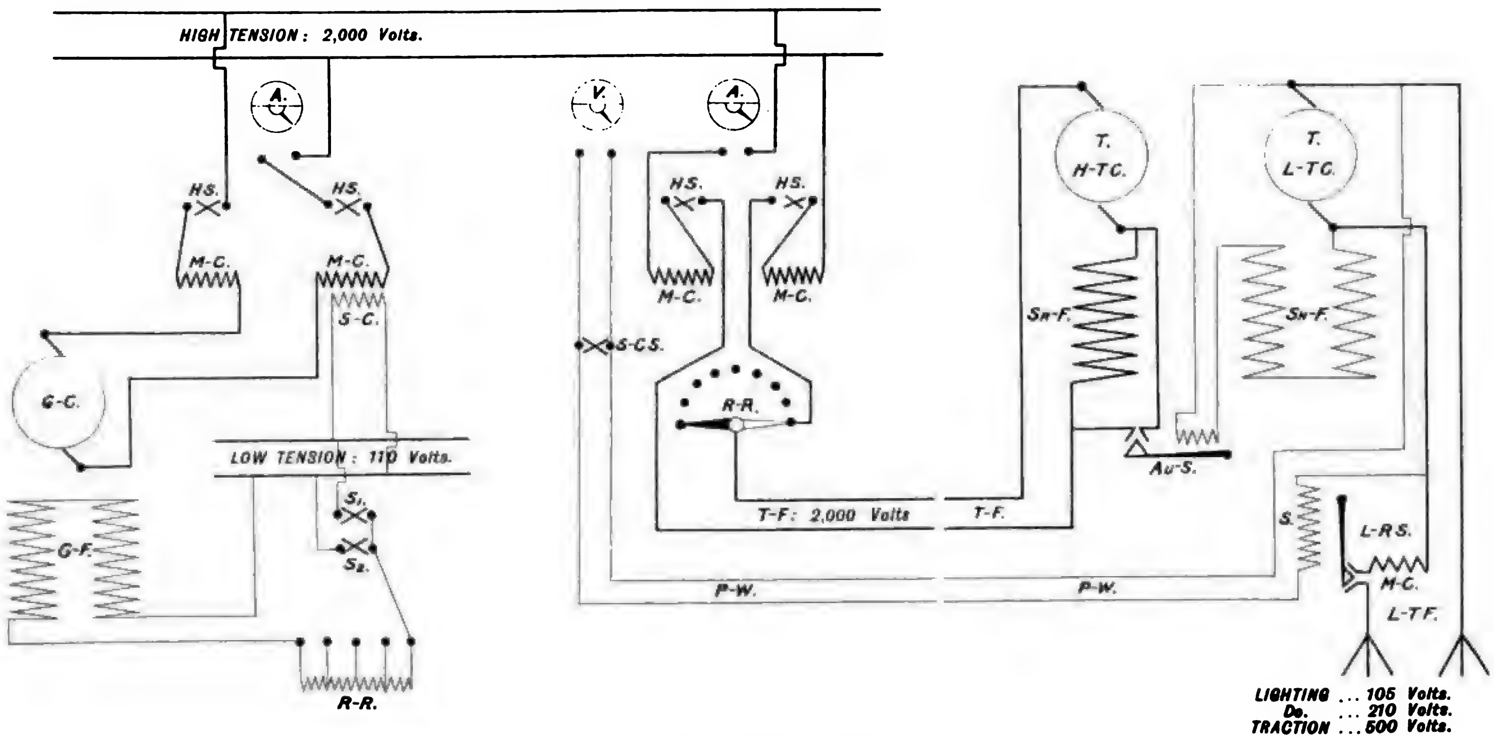
To illustrate Mr. S. L. Thacker's Paper on "Walsall Corporation Electric Supply."

Central Station.

Fig. 1.—Generator-panel.

Fig. 2.—Transformer-panel.

Fig. 3.—Sub-station.



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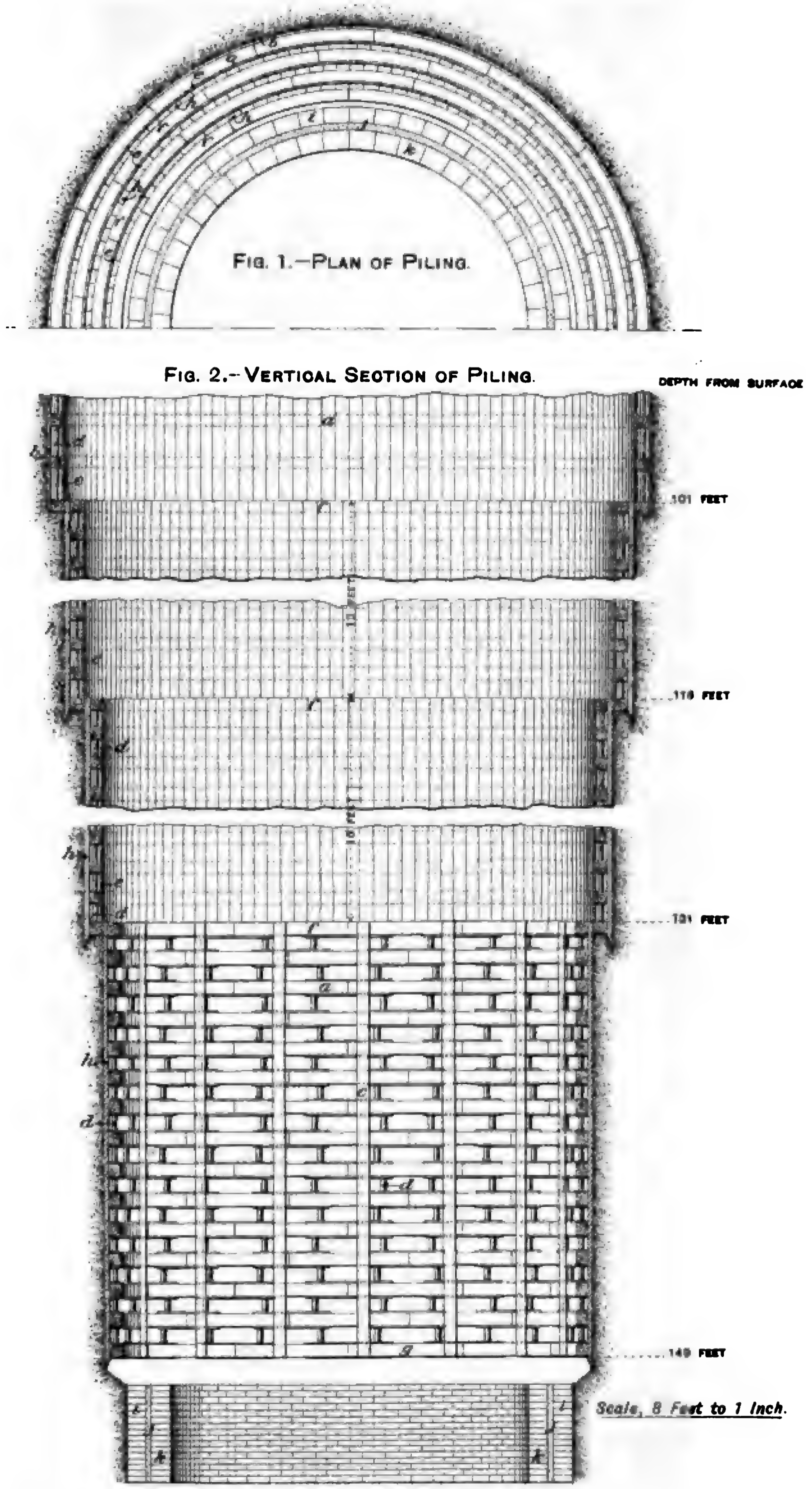
The Institution of Mining Engineers.
Transactions.1906-1907.
Vol. XXXII, Plate XVI.

To illustrate Mr. A. L. Steavenson's Notes on "Bowburn Winning."



The North of England Institute of Mining & Mechanical Engineers
Transactions. 1906-1907
Vol. LVII, Plate II.
Andw. Reid & Compy. Ltd. Newcastle upon Tyne

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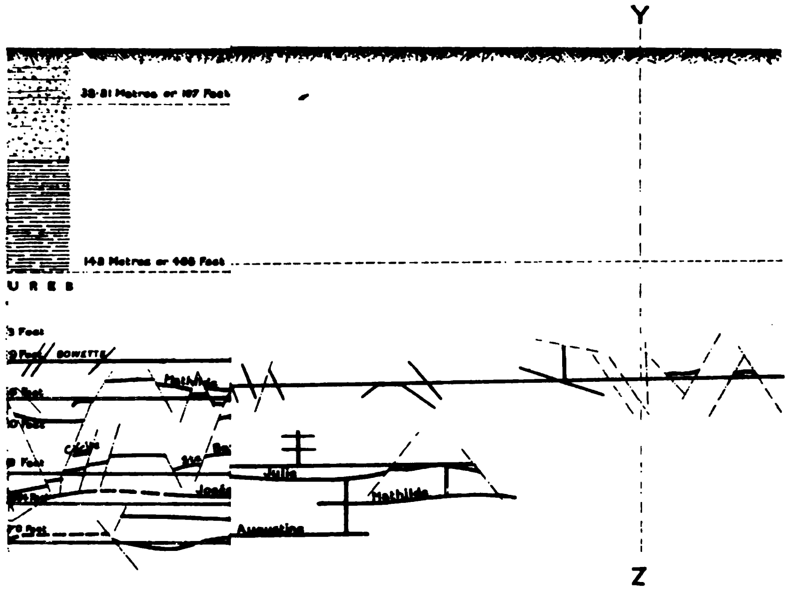

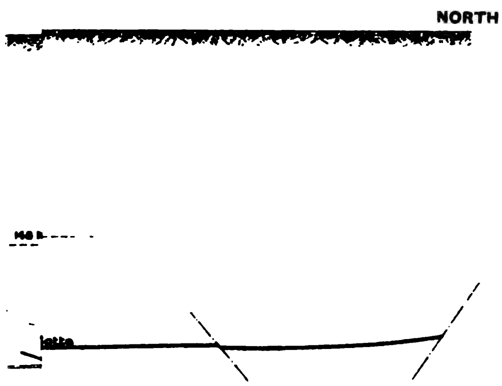

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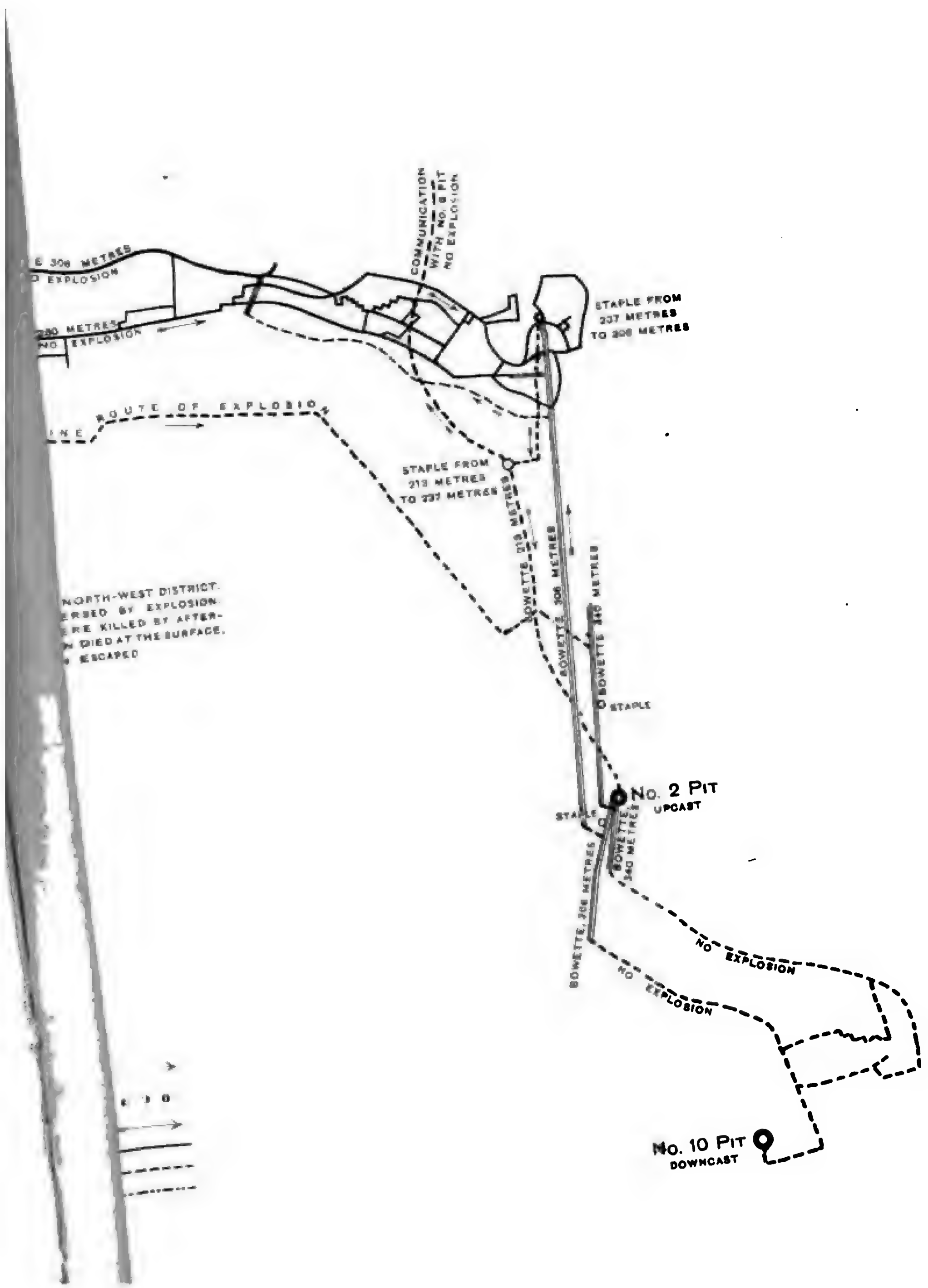

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N DIED AT THE SURFACE.
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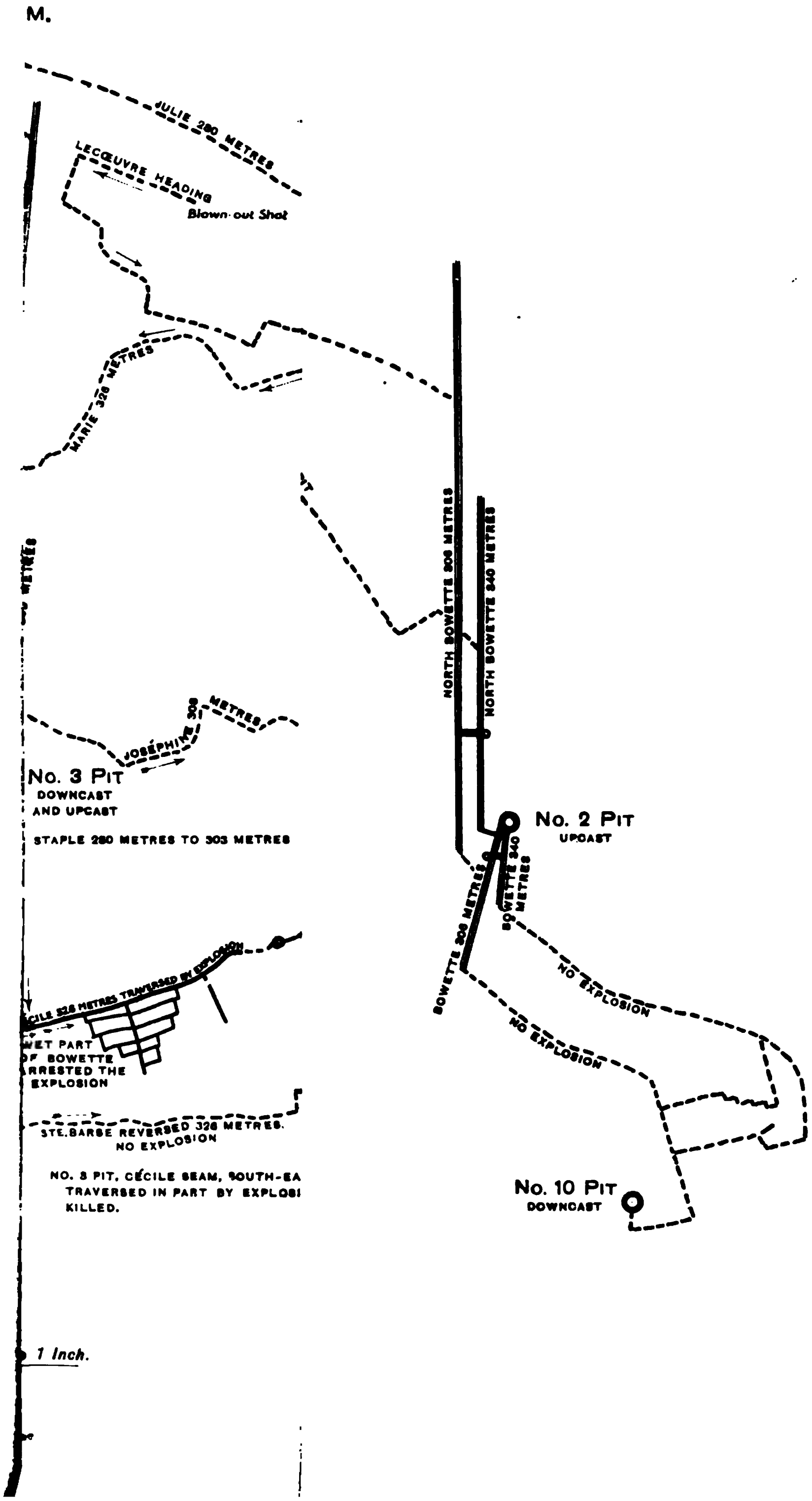
M.
JULIE 280 METRES
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NORTH BOWETTE 340 METRES
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No. 3 PIT
DOWNCAST
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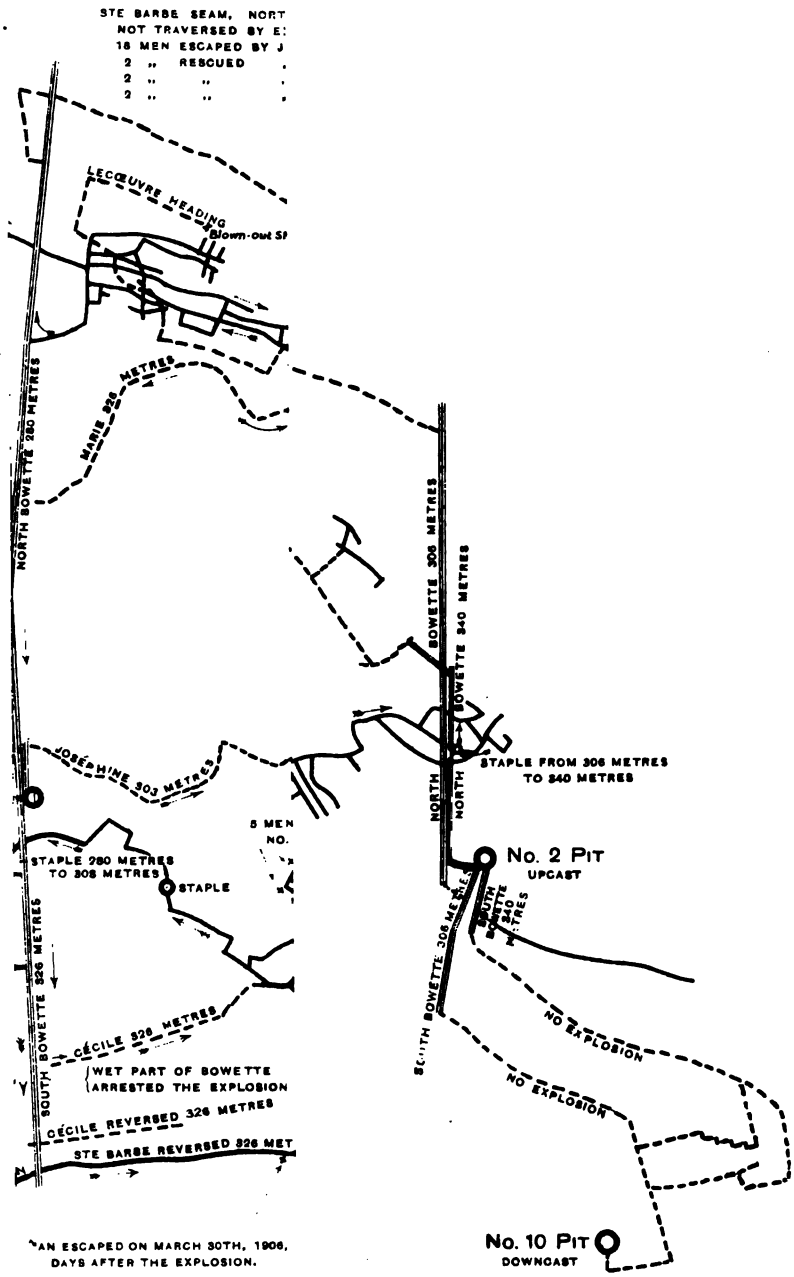
ɪE SEAM.

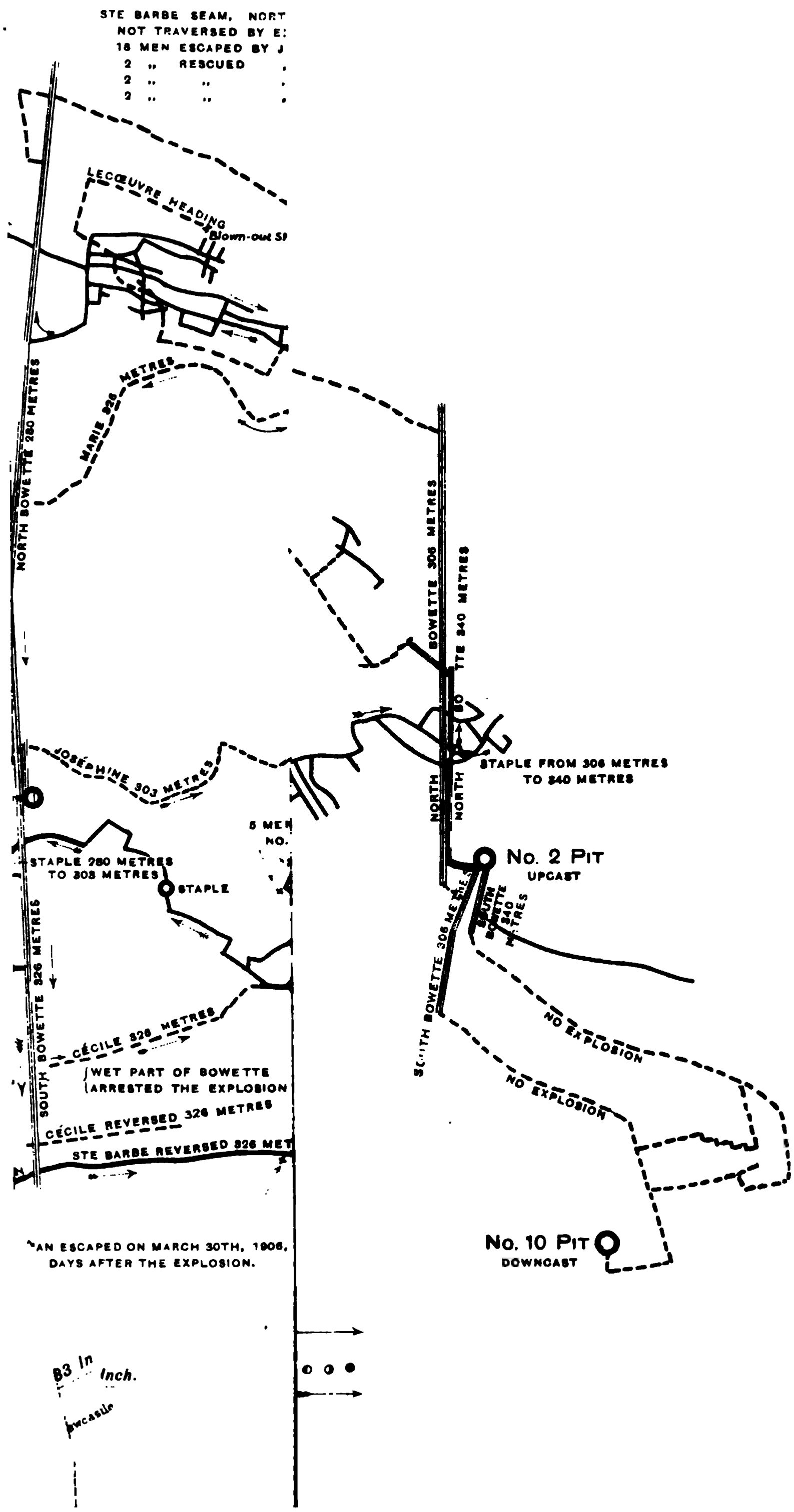


AN ESCAPED ON MARCH 30TH, 1906,
DAYS AFTER THE EXPLOSION.

3 In Inch.

wcastle

...E SEAM.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Blown-out Sh
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TTE 340 METRES
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SOUTH BOWETTE 326 METRES
SOUTH BOWETTE 306 METRES
SOUTH BOWETTE 340 METRES
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STE BARBE REVERSED 326 MET
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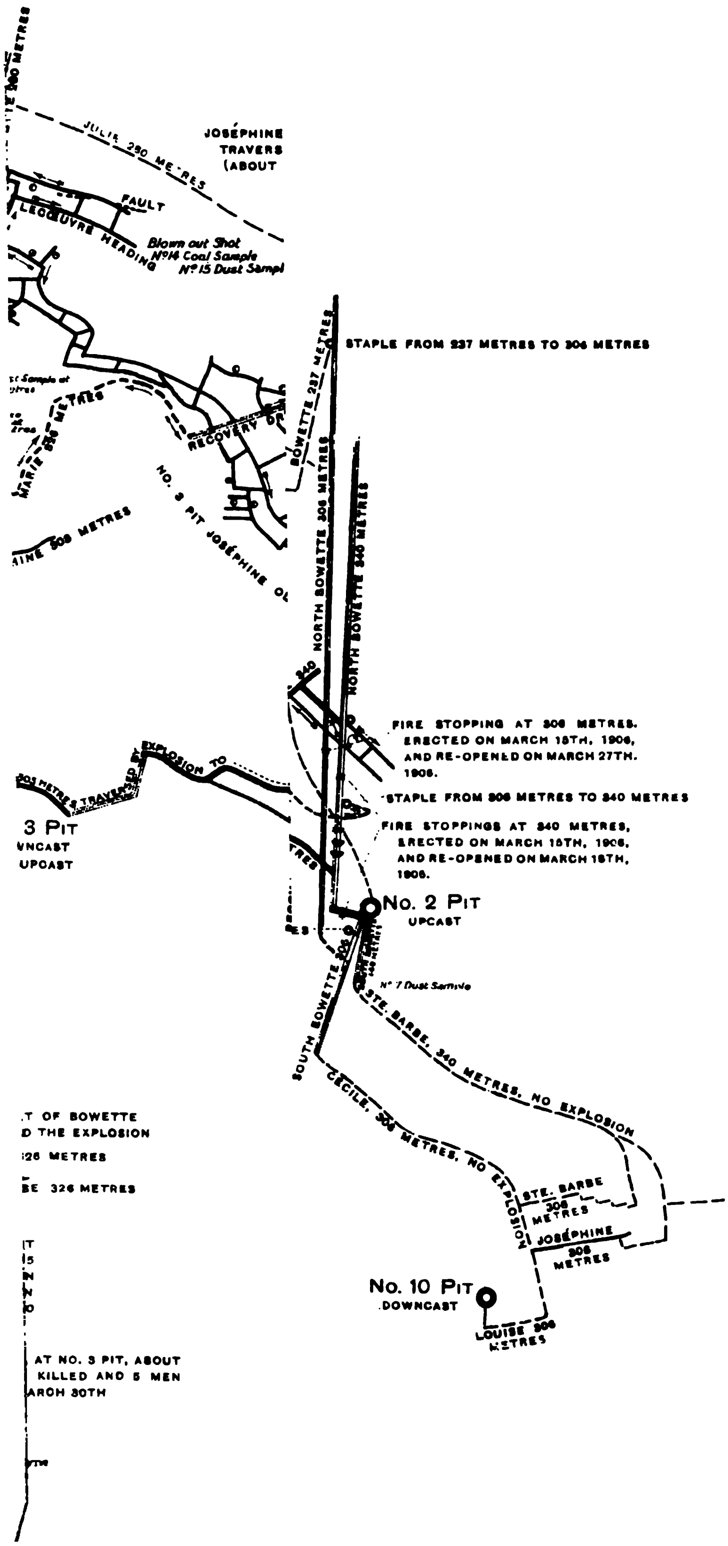
AN ESCAPED ON MARCH 30TH, 1906,
DAYS AFTER THE EXPLOSION.
No. 10 PIT
DOWNCAST
Inch.

SEAM.


JOSÉPHINE
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(ABOUT
JULIE 290 METRES
FAULT
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Nº14 Coal Sample
Nº15 Dust Sampl
STAPLE FROM 237 METRES TO 306 METRES
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RECOVERY DR
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NO. 3 PIT JOSÉPHINE OL
AINE 306 METRES
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AND RE-OPENED ON MARCH 27TH.
1906.
306 METRES TRAVERSED BY EXPLOSION TO
STAPLE FROM 306 METRES TO 340 METRES
3 PIT
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ERECTED ON MARCH 15TH, 1906,
AND RE-OPENED ON MARCH 18TH,
1906.
No. 2 PIT
UPCAST
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SOUTH BOWETTE 306
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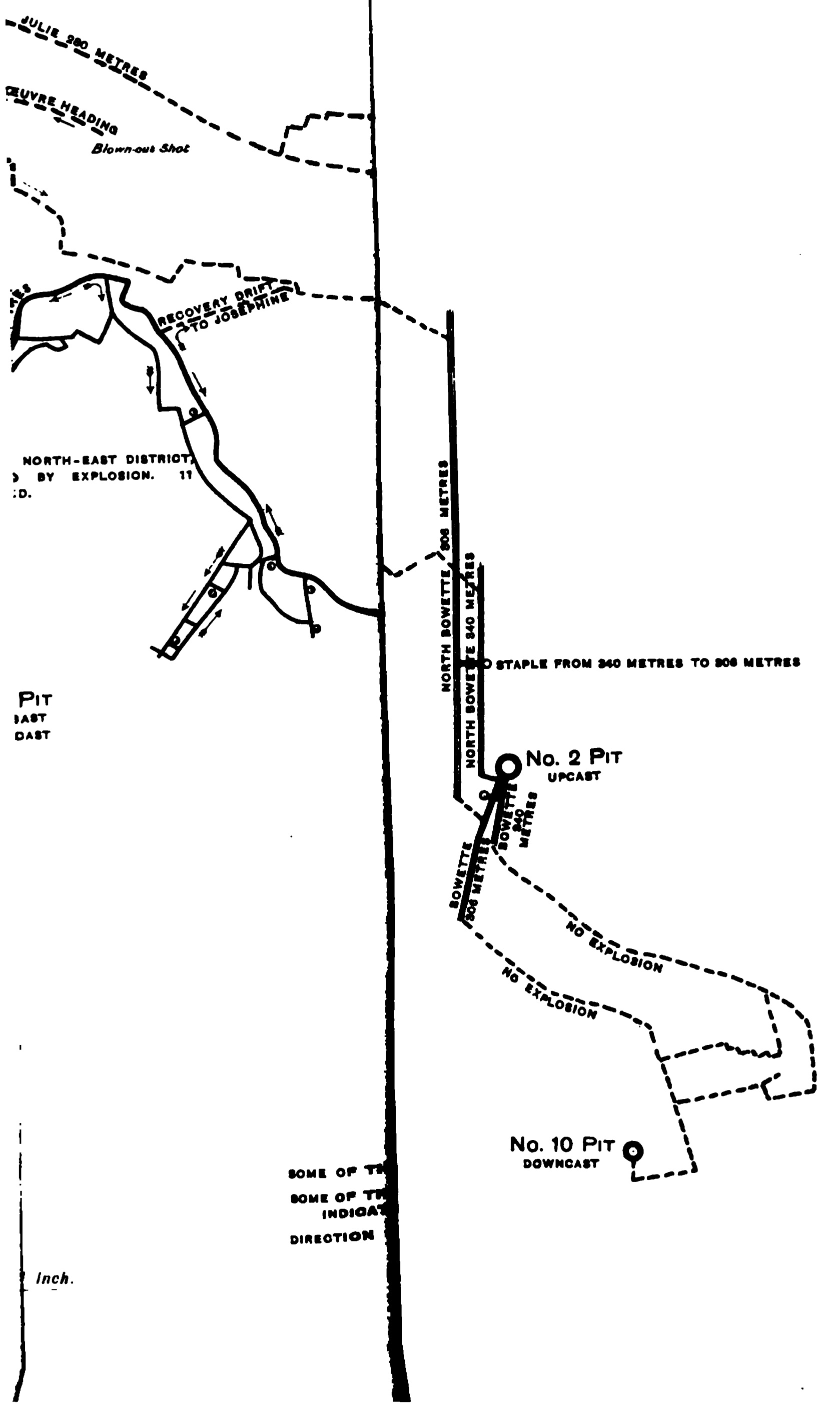
CÉCILE, 306 METRES, NO EXPLOSION
.T OF BOWETTE
D THE EXPLOSION
326 METRES
BE 326 METRES
STE. BARBE
306
METRES
JOSÉPHINE
306
METRES
No. 10 PIT
DOWNCAST
LOUISE 306
METRES
AT NO. 3 PIT, ABOUT
KILLED AND 5 MEN
ARCH 30TH


JULIE 290 METRES
HEADING
Blown-out Shot
RECOVERY DRIFT TO JOSEPHINE
NORTH-EAST DISTRICT
BY EXPLOSION.
PIT
NORTH BOWETTE 306 METRES
NORTH BOWETTE 340 METRES
STAPLE FROM 340 METRES TO 306 METRES
No. 2 PIT
UPCAST
BOWETTE 340 METRES
BOWETTE 306 METRES
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NO EXPLOSION
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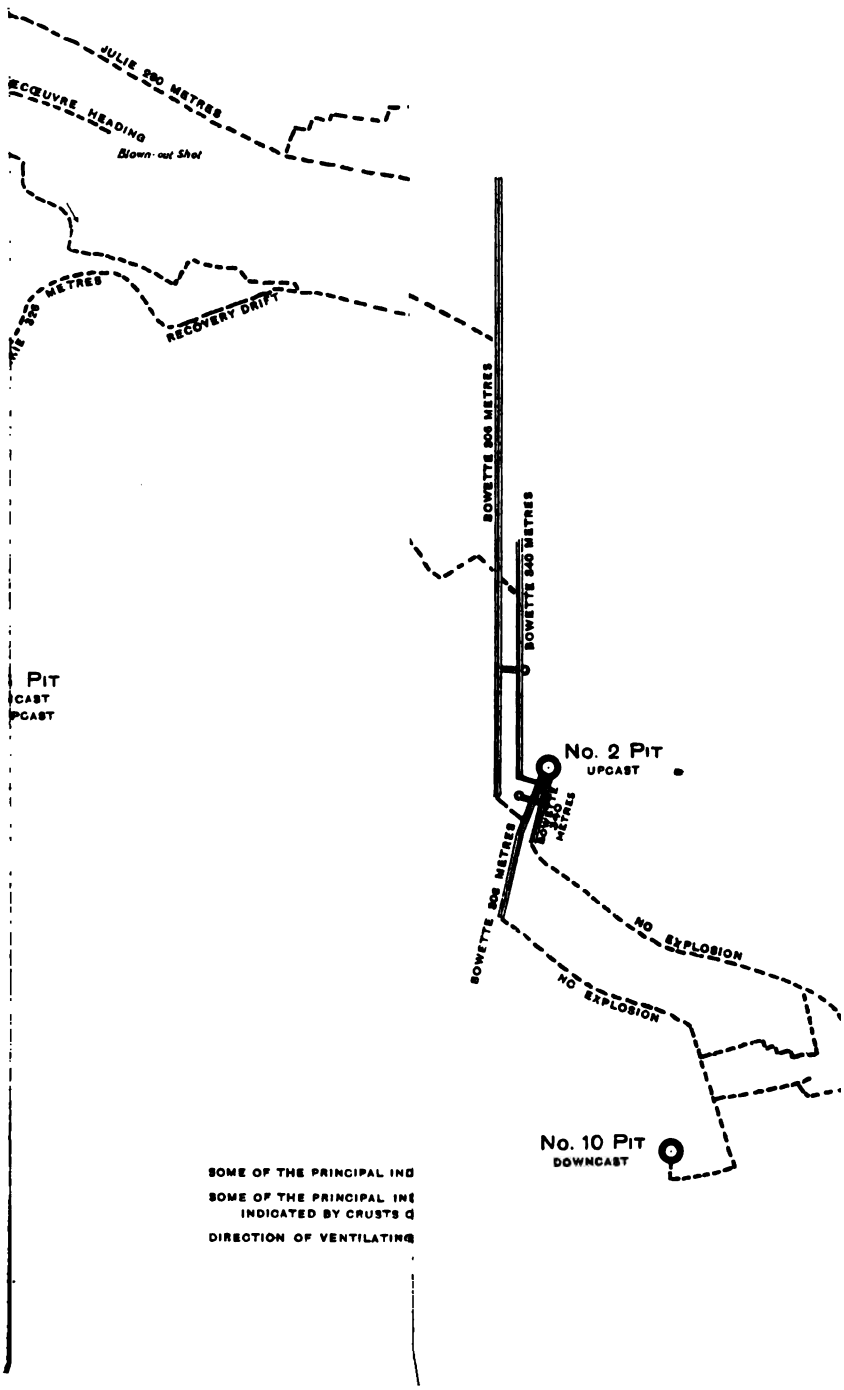
DOWNCAST
DIRECTION
Inch.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SOME OF THE PRINCIPAL IND
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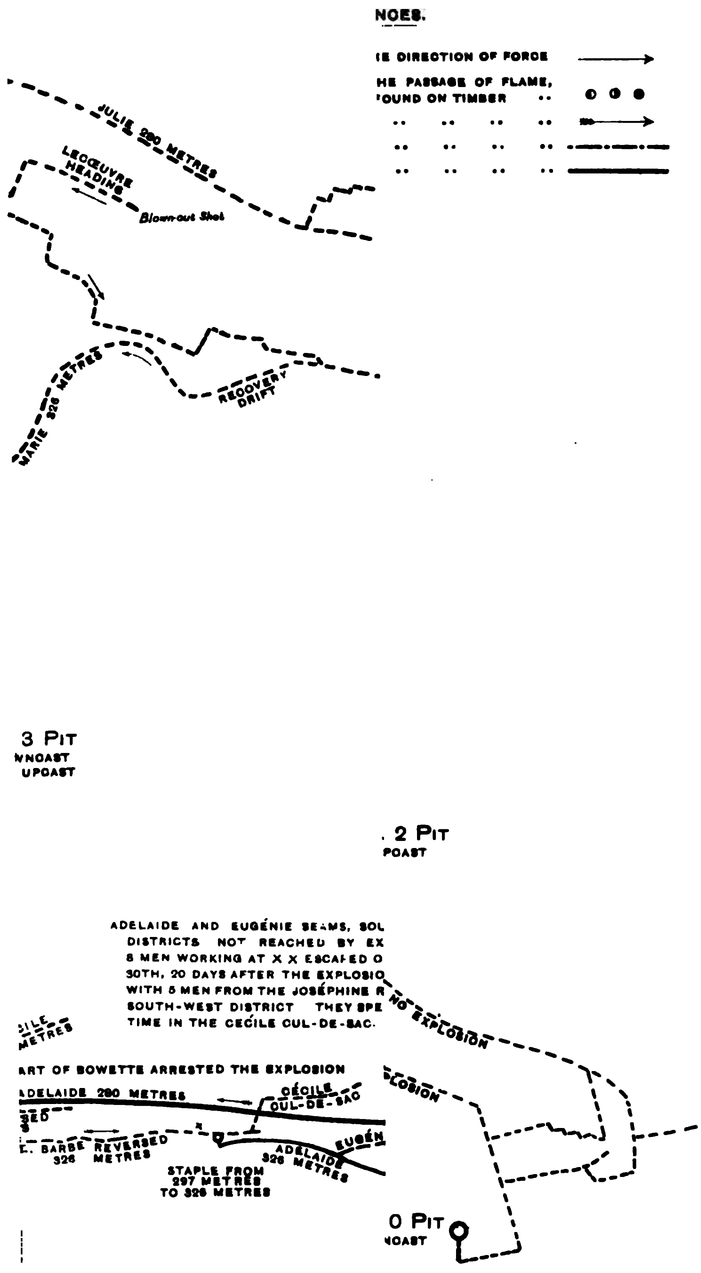
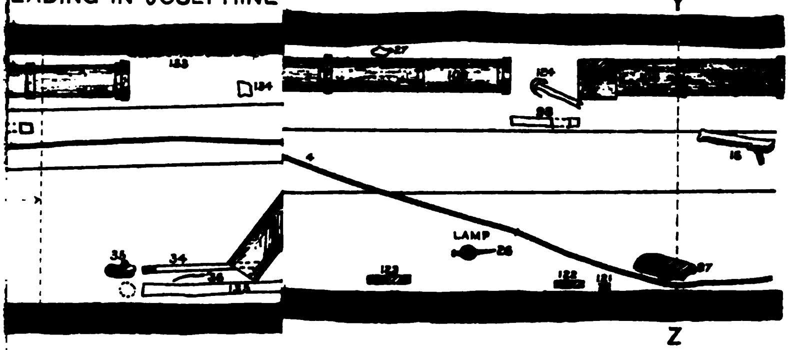
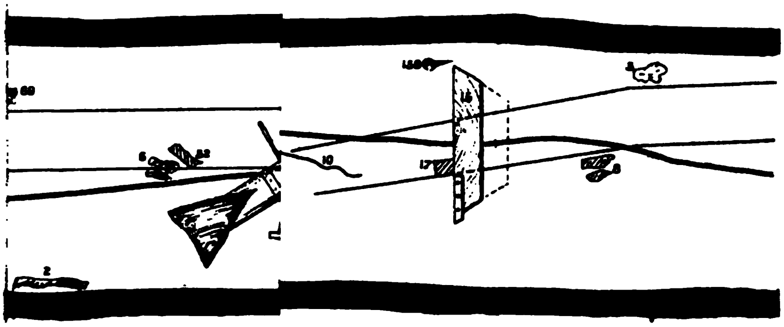


r 8.333 Inches to 1 Inch.

L^td Newcastle upon Tyne

...EADING IN JOSEPHINE





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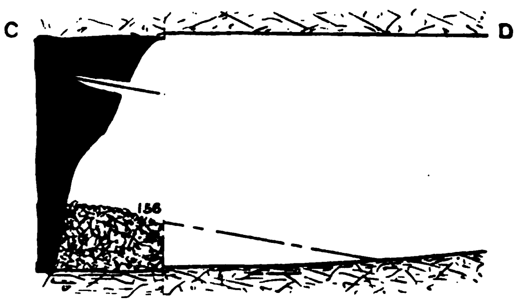

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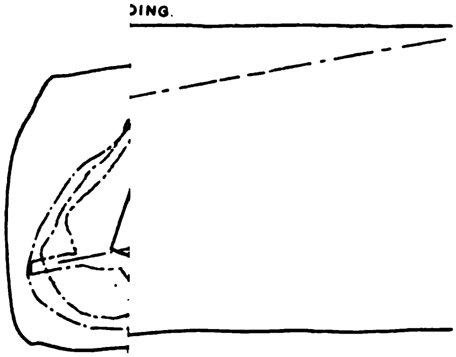


...stle upon Tyne.

To illustrate Mr. J. Bentley's Paper on "Improved Constructions of Rails and Rail-joints" etc.

Fig. 1.—Plan of Bridge-rail.

Fig. 2.—Plan of Bridge-rail.

Fig. 7.—Side View of Chair.

Fig. 8.—End View of Chair.

Fig. 4.—Side View of Chair.

Fig. 5.—End View of Chair.

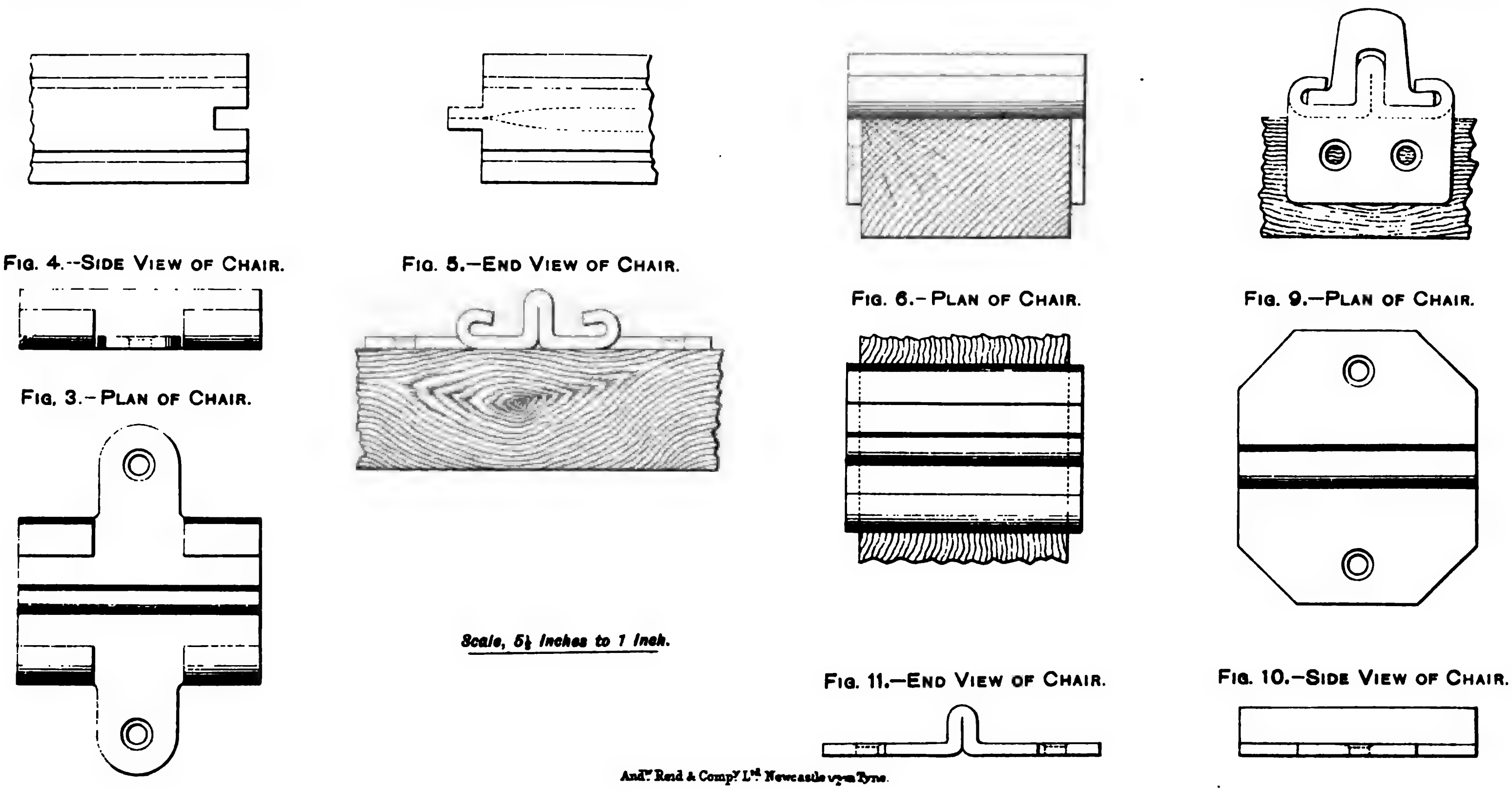
Fig. 6.—Plan of Chair.

Fig. 9.—Plan of Chair.

Fig. 3.—Plan of Chair.

Fig. 11.—End View of Chair.

Fig. 10.—Side View of Chair.



Scale, 5½ Inches to 1 Inch.

Andw. Reid & Compy. Ltd. Newcastle-upon-Tyne.

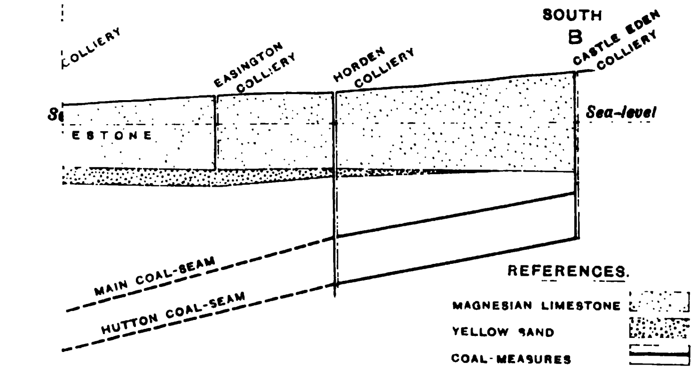
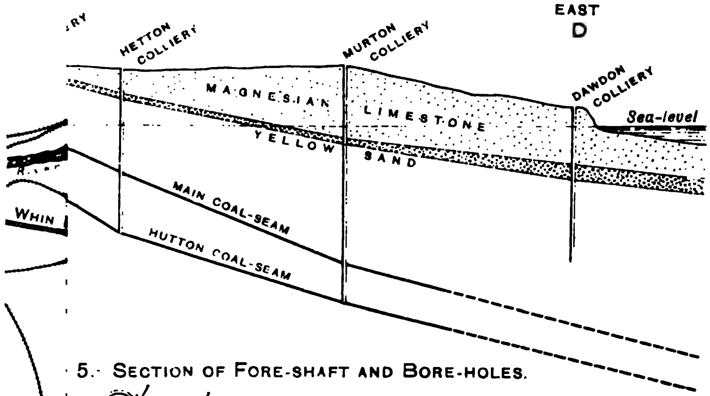
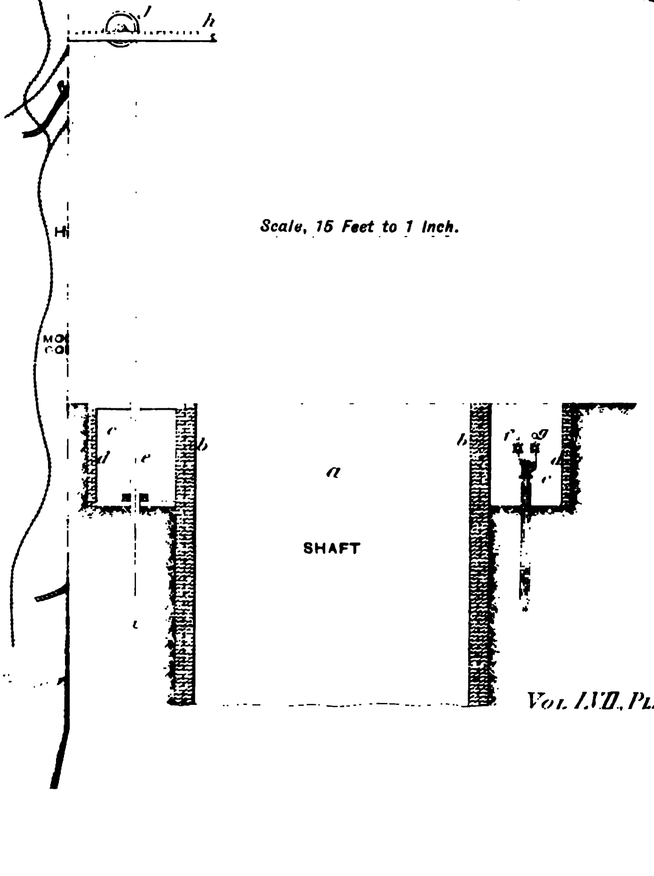
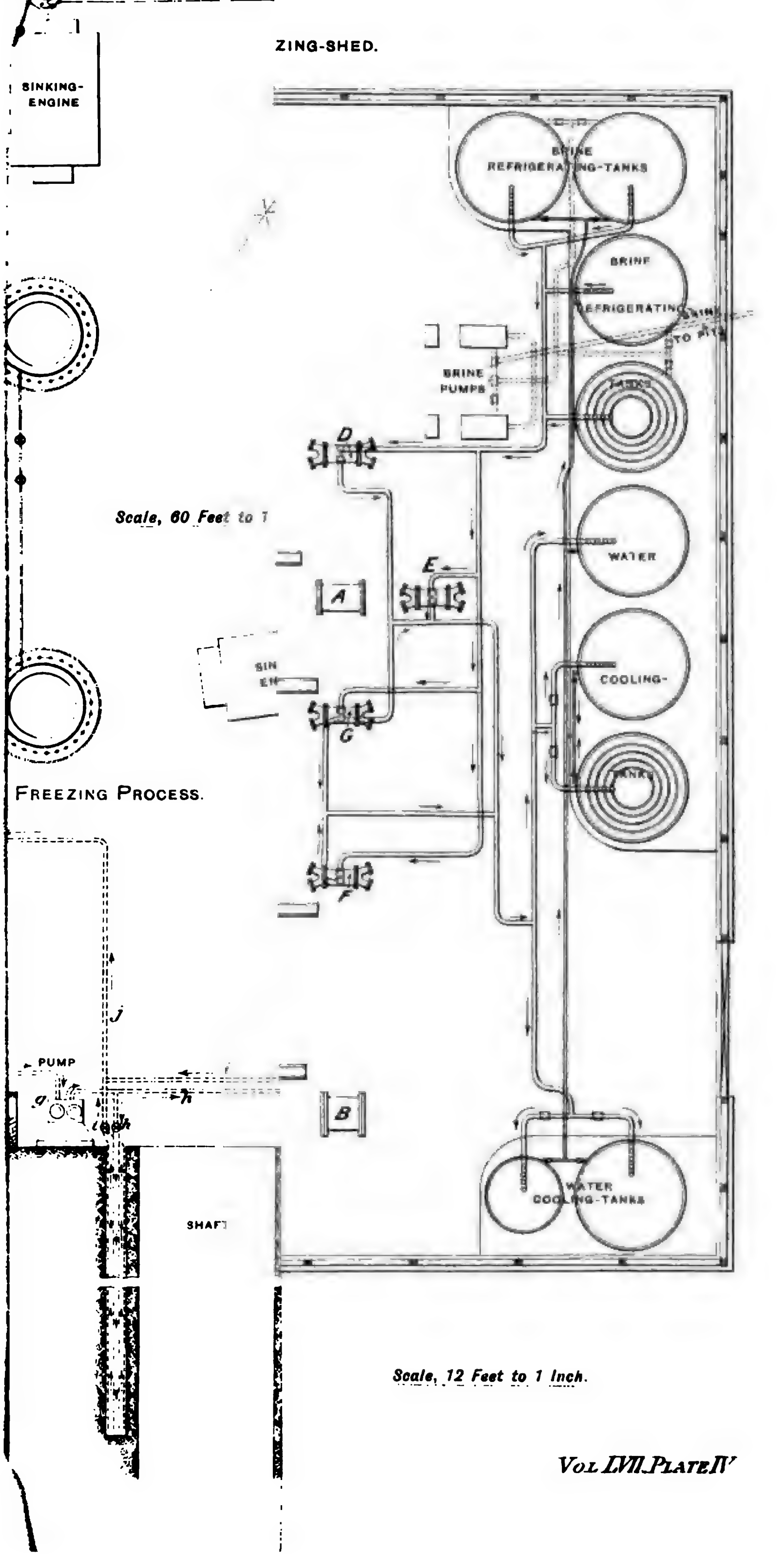


Fig. 1 Fig. 3.- Geological Section on Line CD of Fig. 1.



5.- Section of Fore-shaft and Bore-holes.




ZING-SHED.
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BRINE REFRIGERATING-TANKS
BRINE REFRIGERATING TANKS
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WATER COOLING- TANKS
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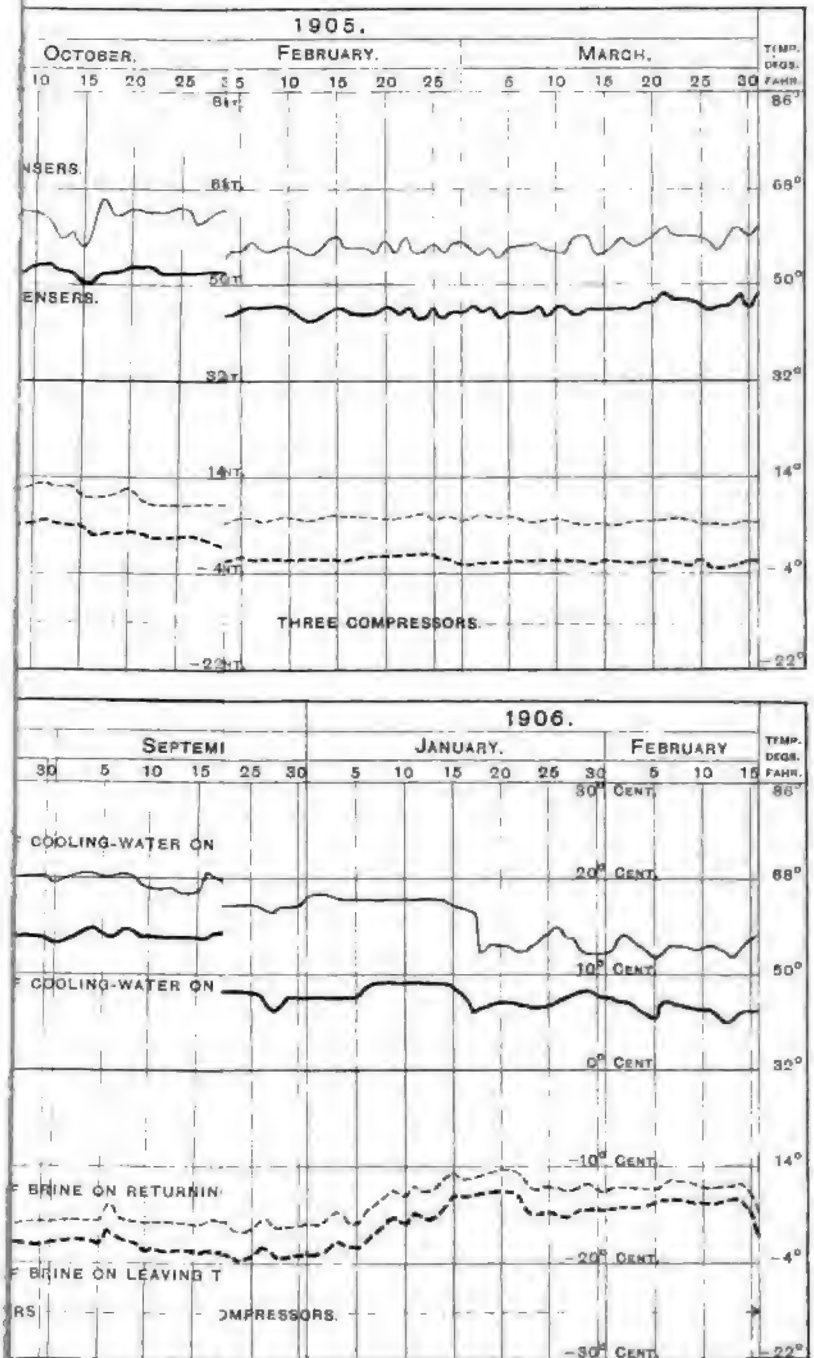
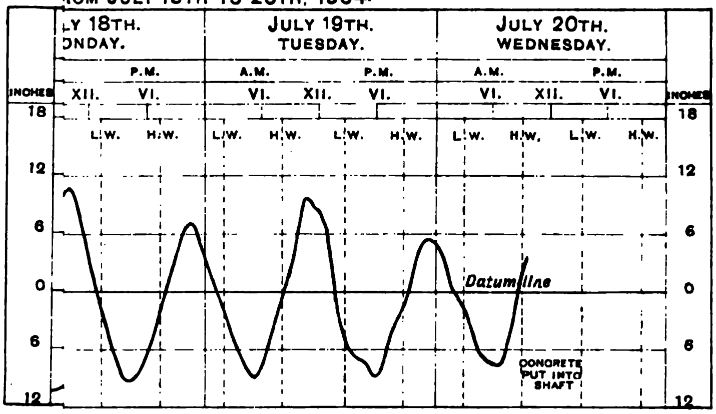
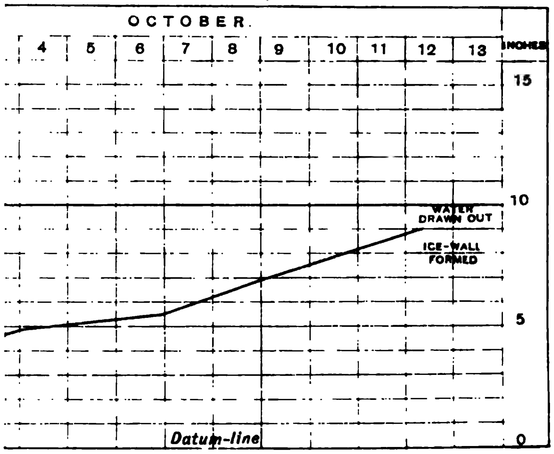
URES OF BRINE AND



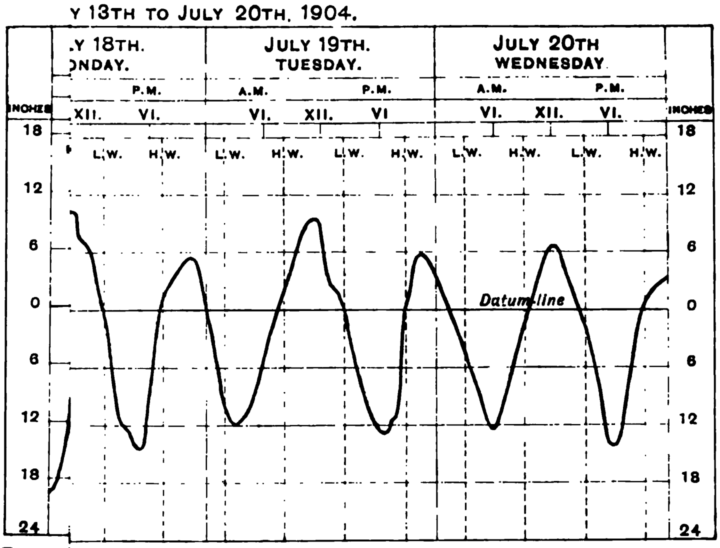
...rom July 13th to 20th, 1904.



...ater due to the Formation of the Ice-wall
...r 22nd to October 12th, 1904.



...y 13th to July 20th, 1904.



ɔBER 31st, TO DECEMBER 2nd, 1904.

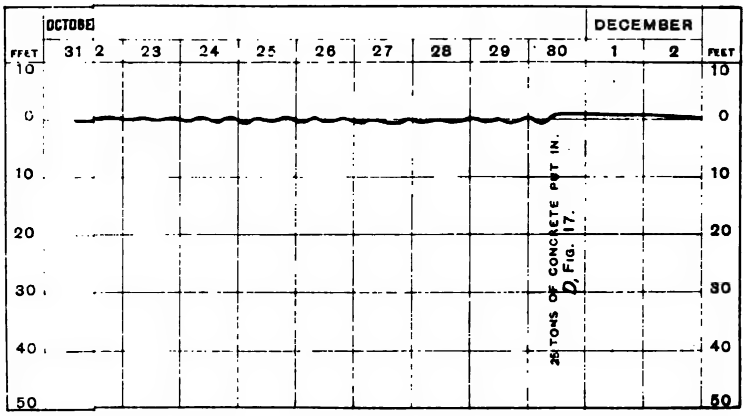


FIG. 17.

CONC. ICE-WALL FROM JANUARY 18TH TO MARCH 4TH, 1905.

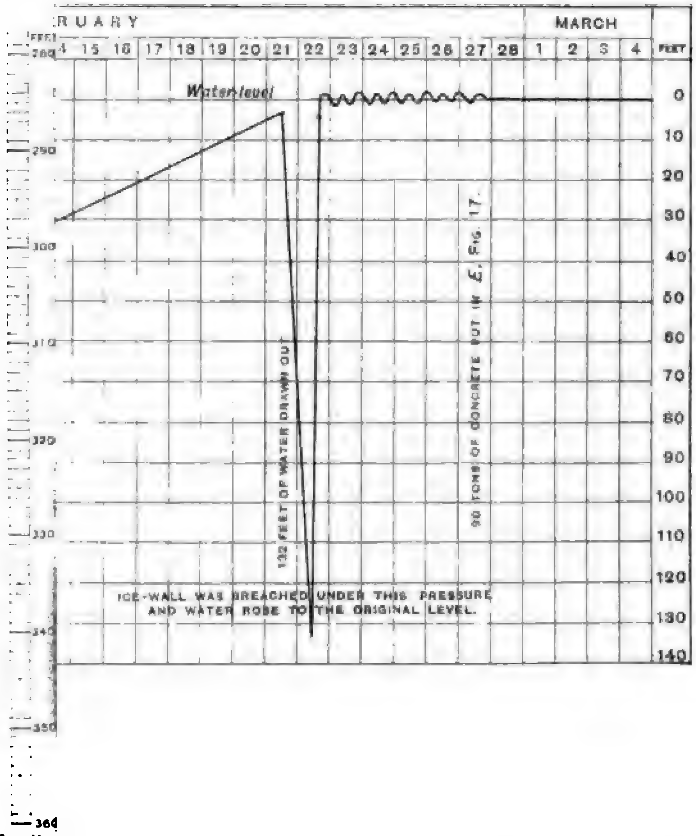
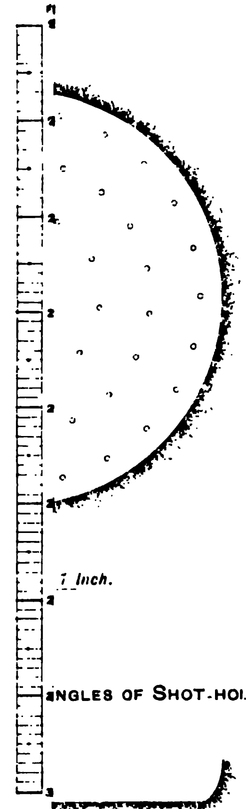


Fig. 2(... ition of Shot-holes. in The... h Frozen Ground.



...ngles of Shot-holes.

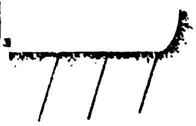


Fig. ... at In...

... 1 Inch.

... e Ring, at a Depth ... tlereagh Shaft, ... 3th, 1906.

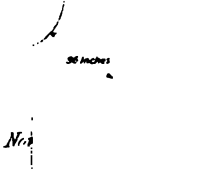
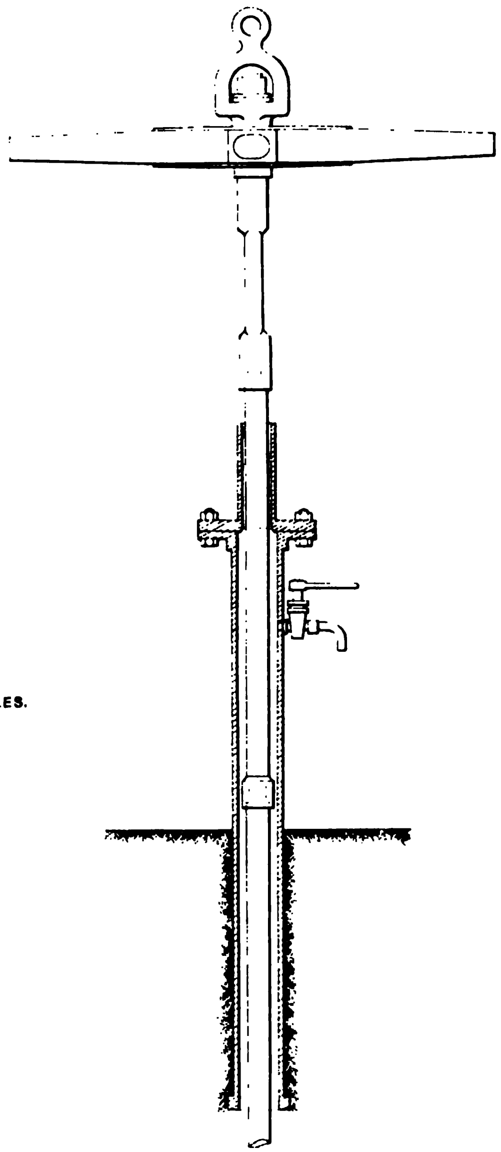


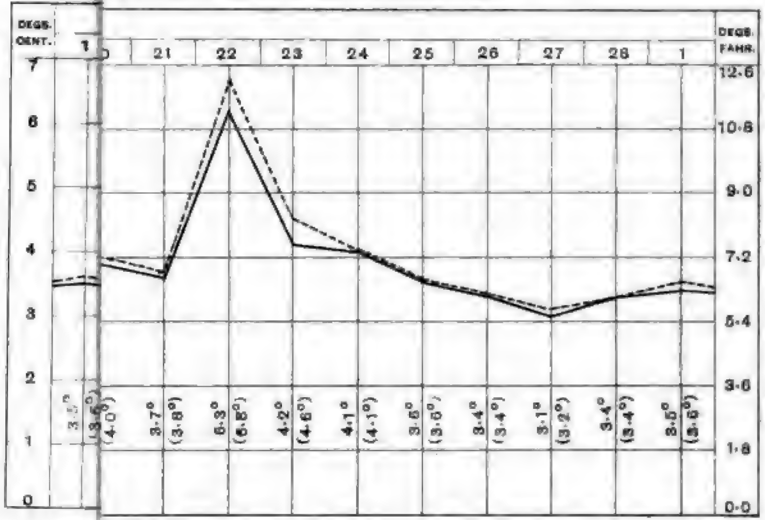
Fig. 26.—Elevation of Stuffing-box for Boring against Water



Scale, 1 Foot to 1 Inch.

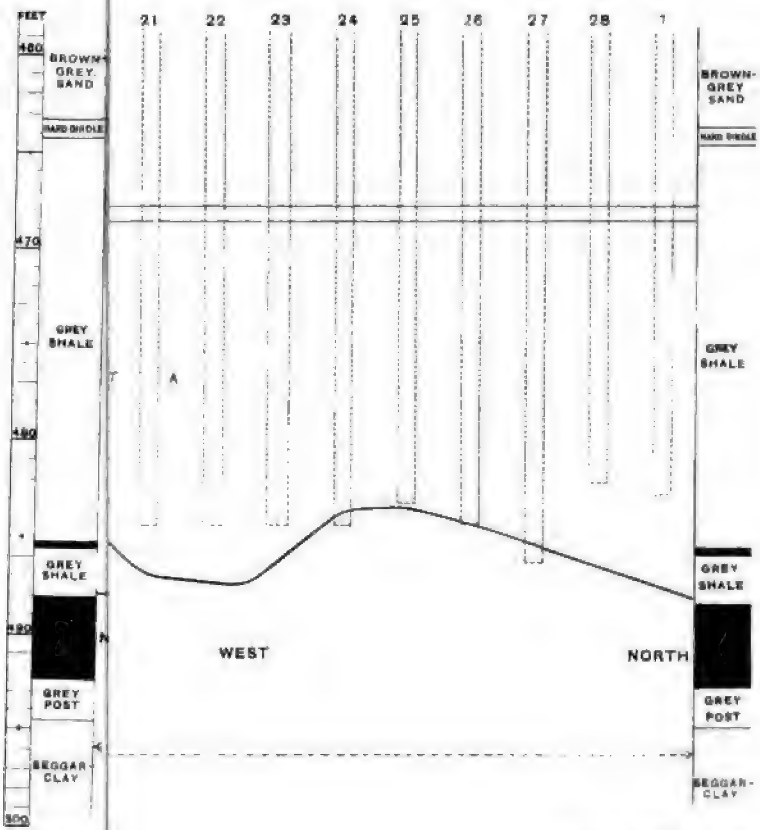
[redacted]

SHAFT, ON FEBRUARY 19TH AND 23RD, 1905.
18·8° CENT. ON EACH DATE RESPECTIVELY.



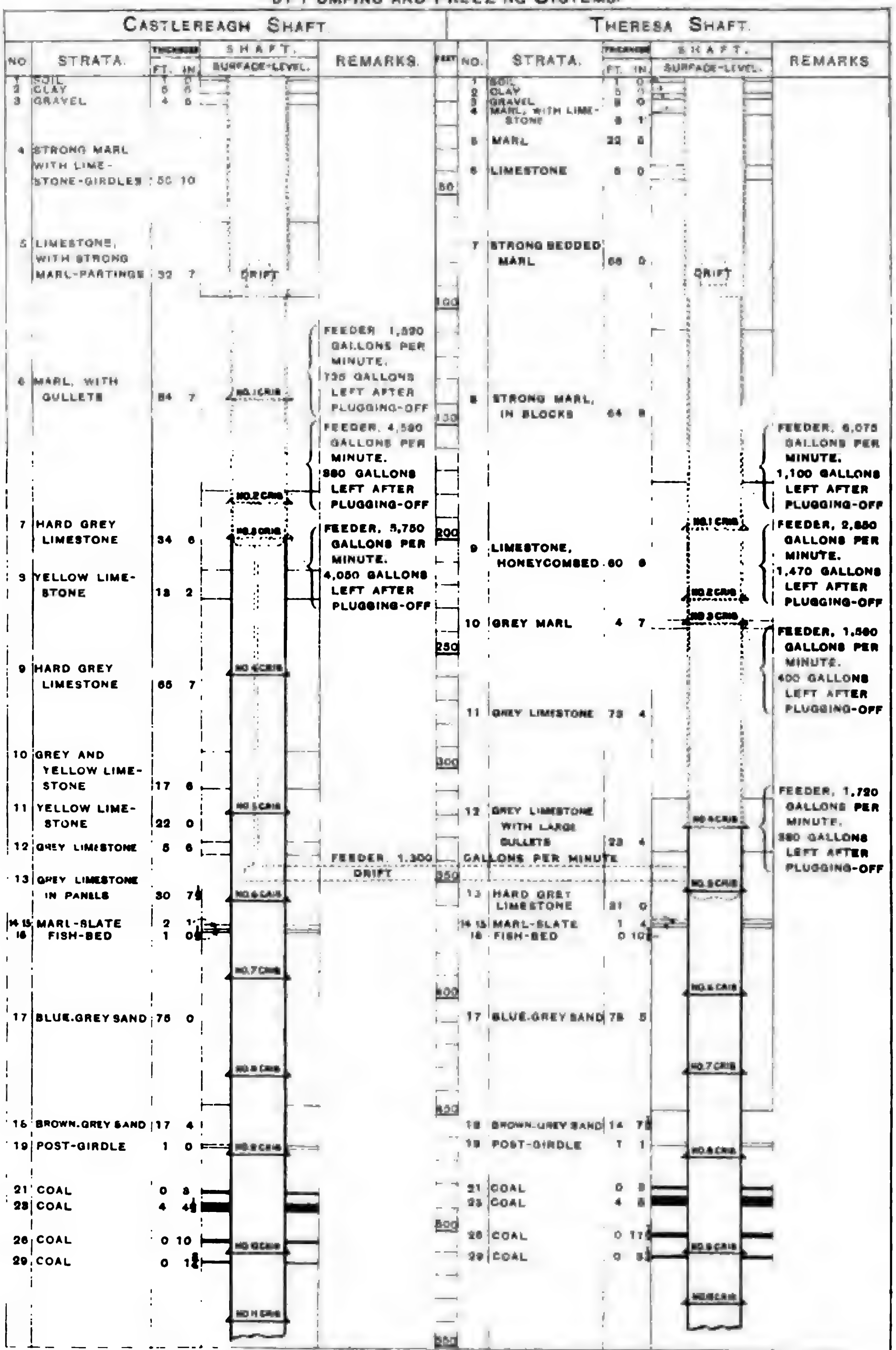
), 1905.

H SHAFT.



To illustrate Mr. E. S. Wood's Paper on "Sinking through Magnesian Limestone," etc.

FIG. 31.—SECTIONS OF STRATA SUNK THROUGH IN CASTLEREAGH AND THERESA SHAFTS, BY PUMPING AND FREEZING SYSTEMS.



REFERENCES.

WORK DONE PREVIOUS TO ADOPTION OF FREEZING PROCESS IN 1905
WORK DONE BY FREEZING PROCESS

Scale, 80 Feet to 1 Inch.

Andw. Reid & Compy. Ltd. Newcastle upon Tyne